# Technical Requirements Document (TRD)

APPENDIX "D"

NPOESS SYSTEM EDR REQUIREMENTS

for

NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM (NPOESS) SENSORS

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# APPENDIX D. NPOESS SYSTEM EDR REQUIREMENTS

# RECORD OF CHANGES

| Version 4a pages include changes resulting from: | CCBD | Pages Affected |
|---|---|---|
| | 97003 | D-22 |
| | 97004 | D-16 |
| | 97005 | D-15 |
| | 97007 | D-16 |
| | 98006 | D-33 |
| | 98007 | D-25 |
| | 98018 | D-16 |
| Version 4b includes: | | |
| | 98043 | D-4,-4a. |
| Version 4c includes: | | |
| | 98019 | D-13 |
| | 98023 | D-14 |
| | 98028 | D-6 |
| | 98044 | D-33 |
| | 98048 | D-6 |
| | 98070 | D-16 |
| | 98072 | D-15 |
| Version 4d includes: | | |
| | 98084 | D-32 |
| | 98086 | D-15 |
| | 98091 | D-3,-4,-6,-7,-10,-15 -18,-20,-23,-39,-44 |
| | 98093 | D-8 |
| | 98094 | D-20 |
| | 98102 | D-3 |
| | 98103 | D-4 |
| | 98107 | D-22 |
| | 98114 | D-19 |

## 40.1 Conventions/General EDR Requirements

### 40.1.1 Requirements Format

EDR requirements are specified by a general definition of the required data content, the units for the reported data, and a set of attributes. These attributes fall into four categories: (1) those that further define data content in a precise, quantitative manner, (2) those that constrain the quality of the data to be provided, (3) those that constrain the reporting frequency for the EDR, and (4) the timeliness of EDR delivery to users. The attributes addressing data content are horizontal and vertical cell size, horizontal and vertical reporting interval, and horizontal and vertical coverage. The attributes addressing data quality are measurement uncertainty, measurement accuracy, measurement precision, long term stability, and mapping uncertainty. The primary attributes addressing reporting frequency are maximum local average revisit time and maximum local refresh. All of these attributes apply to data products, not to sensor performance characteristics, and are defined in the Glossary. The EDR requirements format is to address the data content attributes first, then the data quality attributes, and finally the reporting frequency attributes. The timeliness requirement is the same for all EDRs, and is specified as a global requirement in the "Data Availability" section (Sec. 3.2.1.2).

General EDR requirements fall into two classes: (a) explicit requirements on the EDR content, quality, refresh, and timeliness, and (b) requirements to be derived by the contractor based on requirements for other EDRs. The explicit and application-related requirements are specified below.

TRD40.1.1-1
If a derived requirement conflicts with an explicit requirement and/or another derived requirement, the most stringent requirement shall be satisfied.

### 40.1.2 Key EDRs/Attributes

Attributes marked with an asterisk are key attributes. A key EDR is one for which at least one attribute is key. Key EDRs are marked with an asterisk. Key attribute names and threshold values are also in bold font. Compliance with the TRD requires satisfaction of all EDR thresholds, whether the attribute or its EDR is key or not.

### 40.1.3 Attribute Values

Unless otherwise specified, attribute values are to be interpreted as upper bounds anywhere in the area where measurements are obtained, including the edge of the measuring sensor field of regard. A threshold or objective is "met" or "satisfied" if the system performance value is less than or equal to the specified value.

### 40.1.4 Attribute Values Expressed as Percentages

Unless otherwise specified, a percentage appearing as a value for an attribute is to be interpreted as the percentage of the true value of the attribute. For any attribute where a percentage and a numerical value are specified, the greater of the two is the requirement.

### 40.1.5 Vertical Height

Vertical height is measured either by atmospheric pressure or by height above the earth's surface. A value of zero km for height refers to the earth's surface. Negative values of height refer to depth below the earth's surface (land or water).

### 40.1.6 Specification of Attributes at Nadir

Specification of horizontal cell size or horizontal spatial resolution at nadir does not imply that data must be acquired from a cross-track scanning sensor. The data may be acquired from a conically scanning sensor or any other sensor as long as the horizontal cell size or resolution along the satellite ground track does not exceed the nadir upper

bound. For an EDR for which horizontal cell size is specified only at nadir, cell size is allowed to grow away from nadir as a normal function of the look angle.

### 40.1.7 Impact of Weather Conditions on EDR Requirements

The requirements for “clear” conditions are more stringent and apply when atmospheric conditions are such that infrared sensing (or any comparably capable technology) can be applied. The requirements for “cloudy” conditions are less stringent and apply when atmospheric conditions preclude the use of infrared sensing (or any comparably capable technology), but which can be met by microwave sensing (or any comparably capable technology). For guidance purposes, the government recommends that “clear” refer to less than 50 % cloud cover and “cloudy” refer to greater than or equal to 50 % cloud cover. Except for cloud EDRs and Space Environment EDRs, which must be met regardless of cloud cover, specification of whether an EDR must be met under clear and/or cloudy conditions is provided for each EDR.

TRD40.1.7-1
The contractor shall specify the conditions under which the requirement to deliver an EDR meeting data content and quality requirements will not be met, regardless of whether it is clear or cloudy.

TRD40.1.7-2
The contractor shall also specify the conditions under which it would recommend delivering an EDR which is incomplete and/or of degraded quality but which is still of potential utility to one or more users.

## 40.2 Key EDRs

### 40.2.1 *Atmospheric Vertical Moisture Profile

An atmospheric vertical moisture profile is a set of estimates of average mixing ratio in three-dimensional cells centered on specified points along a local vertical. For this EDR, horizontal cell size is specified at nadir only. The mixing ratio of a sample of air is the ratio of the mass of water vapor in the sample to the mass of dry air in the sample.

Units: **g**/kg

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.2.1-1 | a. Horizontal Cell Size | 15 km @ nadir | 2 km @ nadir |
| 40.2.1-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.2.1-3 | c. Vertical Cell Size | 2 km | 2 km |
| | d. Vertical Reporting Interval | | |
| 40.2.1-4 | 1. Surface to 850 mb | 20 mb | 5 mb |
| 40.2.1-5 | 2. 850 mb to 100 mb | 50 mb | 15 mb |
| 40.2.1-6 | e. Horizontal Coverage | Global | Global |
| 40.2.1-7 | f. Vertical Coverage | Surface to 100 mb | Surface to 100 mb |
| 40.2.1-8 | g. Measurement Range | 0 - 30 g/kg | 0 - 30 g/kg |
| | **h. *Measurement Uncertainty (expressed as a percent of average mixing ratio in 2 km layers)** | | |
| | **Clear** | | |
| 40.2.1-9 | **1. *Surface to 600 mb** | **Greater of 20 %** or **0.2g/kg (TBR)** | 10 % |
| 40.2.1-10 | 2. 600 mb to 300 mb | **Greater of** 35 % or 0.1g/kg (TBR) | 10 % |
| 40.2.1-11 | 3. 300 mb to 100 mb | **Greater of** 35 % or 0.1g/kg (TBR) | 10 % |
| | **Cloudy** | | |
| 40.2.1-12 | **4. *Surface to 600 mb** | **Greater of 20%** or **0.2g/kg (TBR)** | 10 % |
| 40.2.1-13 | 5. 600 mb to 300 mb | **Greater of** 40 % or 0.1g/kg (TBR) | 10 % |
| 40.2.1-14 | 6. 300 mb to 100 mb | **Greater of** 40 % or 0.1g/kg (TBR) | 10 % |
| 40.2.1-15 | i. Mapping Uncertainty | 5 km | 1 km |
| 40.2.1-16 | j. Maximum Local Average Revisit Time | 6 hrs | 3 hrs |
| 40.2.1-17 | k. Maximum Local Refresh | (TBD) | (TBD) |

### 40.2.2 *Atmospheric Vertical Temperature Profile

An atmospheric temperature profile is a set of estimates of the average atmospheric temperature in three-dimensional cells centered on specified points along a local vertical.

Units: K

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| | a. Horizontal Cell Size | | |
| 40.2.2-1 | 1. Clear, nadir | 18.5 km | 5 km |
| 40.2.2-2 | 2. Clear, worst case | 100 km | (TBD) |
| 40.2.2-3 | 3. Cloudy, nadir | 40 km | 5 km |
| 40.2.2-4 | 4. Cloudy, worst case | 50 km | (TBD) |
| 40.2.2-5 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| | c. Vertical Cell Size | | |
| | Clear | | |
| 40.2.2-6 | 1. Surface to 300 mb | 1 km | (TBD) |
| 40.2.2-7 | 2. 300 mb to 30 mb | 3 km | (TBD) |
| 40.2.2-8 | 3. 30 mb to 1 mb | 5 km | (TBD) |
| 40.2.2-9 | 4. 1 mb to 0.01 mb | 5 km | (TBD) |
| | Cloudy | | |
| 40.2.2-10 | 5. Surface to 700 mb | 1 km | (TBD) |
| 40.2.2-11 | 6. 700 mb to 300 mb | 1 km | (TBD) |
| 40.2.2-12 | 7. 300 mb to 30 mb | 3 km | (TBD) |
| 40.2.2-13 | 8. 30 mb to 1 mb | 5 km | (TBD) |
| 40.2.2-14 | 9. 1 mb to 0.01 mb | 5 km | (TBD) |
| | d. Vertical Reporting Interval | | |
| 40.2.2-15 | 1. Surface to 850 mb | 20 mb | 15 mb |
| 40.2.2-16 | 2. 850 mb to 300 mb | 50 mb | 15 mb |
| 40.2.2-17 | 3. 300 mb to 100 mb | 25 mb | 15 mb |
| 40.2.2-18 | 4. 100 mb to 10 mb | 20 mb | 10 mb |
| 40.2.2-19 | 5. 10 mb to 1 mb | 2 mb | 1 mb |
| 40.2.2-20 | 6. 1 mb to 0.1 mb | 0.2 mb | 0.1 mb |
| 40.2.2-21 | 7. 0.1 mb to 0.01 mb | 0.02 mb | 0.01 mb |
| 40.2.2-22 | e. Horizontal Coverage | Global | Global |
| 40.2.2-23 | f. Vertical Coverage | Surface to 0.01 mb | Surface to 0.01 mb |
| 40.2.2-24 | g. Measurement Range | 180-335 K | 162-335 K (TBR) |
| 40.2.2-25 | Not Used | | |
| | **h. *Measurement Uncertainty** | | |
| | **Clear** | | |
| 40.2.2-26 | **1. *Surface to 300 mb** | **1.6 K/ 1 km layers** | 0.5 K/1 km |
| 40.2.2-27 | 2. 300 mb to 30 mb | 1.5 K/ 3 km layers | 0.5 K/1 km |
| 40.2.2-28 | 3. 30 mb to 1 mb | 1.5 K/ 5 km layers | 0.5 K/1 km |
| 40.2.2-29 | 4. 1 mb to 0.01 mb** | 3.5 K/ 5 km layers | 0.5 K/1 km |
| | **Cloudy** | | |
| 40.2.2-30 | **5. *Surface to 700 mb** | **2.5 K/ 1 km layers (TBR)** | 0.5 K/1 km |
| 40.2.2-31 | 6. 700 mb to 300 mb | 1.5 K/ 1 km layers **(TBR)** | 0.5 K/1 km |
| 40.2.2-32 | 7. 300 mb to 30 mb | 1.5 K/ 3 km layers **(TBR)** | 0.5 K/1 km |
| 40.2.2-33 | 8. 30 mb to 1 mb | 1.5 K/ 5 km layers **(TBR)** | 0.5 K/1 km |
| 40.2.2-34 | 9. 1 mb to 0.01 mb | 3.5 K/ 5 km layers **(TBR)** | 0.5 K/1 km |
| 40.2.2-35 | i. Mapping Uncertainty | 5 km | 1 km |
| 40.2.2-36 | j. Maximum Local Average Revisit Time | 6 hrs | 3 hrs |
| 40.2.2-37 | k. Maximum Local Refresh | (TBD) | (TBD) |

** Measurement Uncertainty as specified in K40.2.2-29 shall be referenced to the Cloudy Horizontal Cell Size thresholds and objectives as listed under K40.2.2-3 and K40.2.2-4.

### 40.2.3 *Imagery

Imagery requirements fall into three classes: (a) explicit requirements on the EDR content, quality, reporting frequency, and timeliness, (b) requirements to be derived based on specific applications utilizing the imagery EDR, such as manual generation of cloud and sea ice data, and (c) requirements to be derived by the contractor based on requirements for other EDRs supported by the imagery. The explicit and application-related requirements are specified below. (Automated generation of cloud data is addressed in other EDRs and therefore will not be addressed below.)

#### 40.2.3.1 Explicit EDR Requirements

Imagery is defined as the measured locally-averaged upwelling radiance or equivalent black body temperature from the earth's surface and atmosphere in one or more spectral bands, where the local averages are reported for the points of a two-dimensional approximately rectangular lattice. (The lattice is only approximately rectangular because of the curvature of the earth.) The form of the weighting function that determines the local average is constrained by the horizontal spatial resolution requirement. The number of spectral bands, band limit values, measurement ranges, and measurement uncertainty requirements are to be derived based on the application-related requirements given below and on the requirements of other EDRs supported by the imagery. However, at least one daytime visible, one nighttime visible, and at least one IR channel are required. Daytime and nighttime visible imagery must be merged so as to minimize the apparent transition across the terminator. Unless otherwise specified, the explicit EDR requirements below apply to each spectral band that is required for the Application-Related requirements of section 40.2.3.2 and at a minimum, to at least one daytime visible, one nighttime visible, and one IR channel (TBR). The explicit horizontal spatial resolution and mapping uncertainty requirements specified below do not apply to microwave imagery.

TRD40.2.3.1-1
Brightness temperatures from each microwave channel and polarization, if applicable, shall be available for display at the sampled resolution.

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| | a. ***Horizontal Spatial Resolution (HSR)** | | |
| 40.2.3.1-2 | **1. Global, at nadir** | **1.0 km** | (TBD) |
| 40.2.3.1-3 | 2. Global, worst case | 2.4 km | 0.65 km |
| 40.2.3.1-4 | **3. Regional, at nadir** | **0.4 km** | (TBD) |
| 40.2.3.1-5 | 4. Regional, worst case | 0.8 km | 0.1 km |
| 40.2.3.1-6 | 5. Nighttime Visible, worst case | 2.6 km | 0.65 km |
| 40.2.3.1-7 | b. Horizontal Reporting Interval | Derived (gapless or near gapless coverage) | Derived (gapless or near gapless coverage) |
| | c. Horizontal Coverage | | |
| 40.2.3.1-8 | 1. Global | Global Resolution | Global Resolution |
| 40.2.3.1-9 | 2. Regional | Up to 1/2 orbit, non-contiguous, commandable by SOC | Up to 1/2 orbit, non-contiguous, commandable by SOC |
| | d. Measurement Range | | |
| 40.2.3.1-10 | 1. Nighttime visible | 4E-9 - 7E-4 W/cm$^2$-sr in 0.4-1.0 $\mp$m band, or equivalent in another band | Includes threshold range |
| 40.2.3.1-11 | 2. Other bands | Derived | Derived |
| 40.2.3.1-12 | e. Measurement Uncertainty | Derived | Derived |
| | f. Mapping Uncertainty | | |
| 40.2.3.1-13 | 1. At nadir | 3 km | (TBD) |
| 40.2.3.1-14 | 2. Worst case | 4 km | 0.5 km |
| 40.2.3.1-15 | **g. *Maximum Local Average Revisit Time** | **4 hrs** | (TBD) |
| 40.2.3.1-16 | **h. *Maximum Local Refresh** | **6 hrs** | (TBD) |
| 40.2.3.1-17 | **i. *Fraction of Revisit Times Less Than a Specified Value** | **At any location at least 75 % of the revisit times will be 4 hours or less** | (TBD) |

## 40.2.3.2 Application-Related Requirements (TBR)

TRD40.2.3.2-1
The content, quality, and reporting frequency of the imagery shall suffice to support the following application-related requirements. These requirements, together with requirements of other EDRs supported by the imagery, determine the derived requirements in the explicit EDR requirement set above and may drive specified values of non-derived attributes to more stringent values. The content of the application-related data products is not part of the content of the imagery EDR. It is assumed that flowdown of application-related requirements to explicit imagery requirements will be performed by contractor simulation and modeling.

### 40.2.3.2.1 Manually Generated Cloud Data

Manually generated cloud data are estimates of cloud cover and cloud type generated by a human analyst viewing the unprocessed and/or processed imagery derived from the unprocessed imagery, e.g., by data fusion, spatial rescaling, image enhancement, etc.

### 40.2.3.2.1.1 Cloud Cover

Cloud cover is defined as the fraction of a given area on the earth's surface for which a locally normal line segment extending between two given altitudes intersects a detectable cloud as defined in the Glossary. For manual analyses, cloud cover is estimated for a single atmospheric layer. Specifically, the altitudes are defined to be the surface of the earth and the altitude where the pressure is 0.1 mb. Haze, smoke, dust, and rain are not to be considered clouds. Cloud cover estimates are generated by a human analyst viewing unprocessed and/or processed imagery for contiguous square areas having side length equal to the horizontal cell size specified below.

Units: Dimensionless

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| | a. Horizontal Cell Size | | |
| 40.2.3.2.1.1-1 | 1. Global | 4 (TBR) times global HSR | 2 times global HSR |
| 40.2.3.2.1.1-2 | 2. Regional | 4 (TBR) times regional HSR | 2 times regional HSR |
| 40.2.3.2.1.1-3 | b. Horizontal Reporting Interval | Horizontal cell size | Horizontal cell size |
| 40.2.3.2.1.1-4 | c. Measurement Range | 0 - 1, 0.1 increments | 0 - 1, 0.1 increments |
| 40.2.3.2.1.1-5 | d. Measurement Uncertainty | 0.1 | 0.1 |

### 40.2.3.2.1.2 Cloud Type

Cloud types are defined as follows:

(1) Altocumulus (AC)
(2) Altocumulus Castellanus (ACCAS)
(3) Altocumulus (standing lenticular) (ACSL)
(4) Altostratus (AS)
(5) Cirrocumulus (CC)
(6) Cirrocumulus (standing lenticular) (CCSL)
(7) Cirrostratus (CS)
(8) Cirrus (CI)
(9) Cumulonimbus (CB)
(10) Cumulonimbus mama (Mammatocumulus) (CBMAM)
(11) Cumulus (CU)
(12) Cumulus Fractus (CUFRA)
(13) Towering Cumulus (TCU)
(14) Stratus Fractus (STFRA)
(15) Nimbostratus (NS)
(16) Stratocumulus (SC)
(17) Stratocumulus (standing lenticular) (SCSL)
(18) Stratus (ST)

Cloud typing not only entails a capability to distinguish between clouds of different types, but also a capability to distinguish clouds from other features, such as snow, cold water, cold land, haze, smoke, dust, etc. Therefore, the following additional types are defined:

(19) Obscured/not cloudy
(20) Clear

A given area is classified (TBR) as "obscured/not cloudy" if there are no detectable clouds within the atmosphere overlying the area and if the average vertical LOS extinction optical thickness of the atmosphere overlying the area is > 0.03 (TBR). A given area is classified (TBR) as "clear" if there are no detectable clouds as defined above

overlying the area and if the average vertical LOS extinction optical thickness of the atmosphere overlying the area is < 0.03 (TBR). Note that other EDRs require the type of non-cloud obscuration to be discerned and identified, e.g., smoke, dust, sand, ash, etc.

Typing is performed by a human analyst viewing unprocessed and/or processed imagery for contiguous square areas having side length equal to the horizontal cell size specified below. The probability of correct typing is defined as the probability that a cell reported as being of type x is in fact of type x, where x is any of the types specified above.

Units: N/A

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| | a. Horizontal Cell Size | | |
| 40.2.3.2.1.2-1 | 1. Global | 10 times global HSR | 2 times global HSR |
| 40.2.3.2.1.2-2 | 2. Regional | 10 times regional HSR | 2 times regional HSR |
| 40.2.3.2.1.2-3 | b. Horizontal Reporting Interval | Horizontal cell size | Horizontal cell size |
| 40.2.3.2.1.2-4 | c. Measurement Range | Clear, obscured/not cloudy, ST, CU, CI | Clear, obscured/not cloudy, all 18 cloud types |
| | d. Probability of Correct Typing | | |
| 40.2.3.2.1.2-5 | 1. Global | 85 % | 90 % |
| 40.2.3.2.1.2-6 | 2. Regional | 85 % | 90 % |

## 40.2.3.2.2 Sea Ice Data

Sea ice data may be generated interactively by a human analyst viewing unprocessed or processed imagery at a computer workstation, or automatically via an algorithm. In addition to determination of ice edge location and ice concentration as described below, analysts will attempt to determine the thickness and size of leads and polynyas based on the imagery.

### 40.2.3.2.2.1 Ice Edge Location

An ice edge is defined as the boundary between ice-covered sea water (ice concentration > 0.1(TBR)) and sea water not covered by ice (ice concentration $\leq$ 0.1(TBR)). Ice concentration is defined as the fraction of a given area sea or water covered by ice. An ice edge is typically provided as a contour on a map or in digital form as a set of latitude/longitude coordinates. The ice edge location error is defined as the distance between the estimated location of an ice edge and the nearest location of a true ice edge.

Units: Degrees latitude and longitude

| Para. No | | Thresholds | Objectives |
|---|---|---|---|
| 40.2.3.2.2.1-1 | a. Horizontal Coverage | North of 36 deg north latitude, south of 50 deg south latitude for sea ice | North of 36 deg north latitude, south of 50 deg south latitude for sea ice |
| 40.2.3.2.2.1-2 | b. Measurement Range | Any latitude, longitude within coverage domain | Any latitude, longitude within coverage domain |
| | c. Measurement Uncertainty | | |
| 40.2.3.2.2.1-3 | 1. Global/Clear | 1 km | (TBD) |
| 40.2.3.2.2.1-4 | 2. Cloudy | 10 km | (TBD) |
| 40.2.3.2.2.1-5 | 3. Deleted | | |
| 40.2.3.2.2.1-6 | 4. Deleted | | |

### 40.2.3.2.2.2 Ice Concentration

Ice concentration is defined as the fraction of a given area of sea water covered by ice. It is typically derived from imagery and reported on ocean geographical charts for areas between contours generated by an analyst.

Units: Dimensionless

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.2.3.2.2.2-1 | a. Horizontal Coverage | North of 36 (TBR) deg north latitude, south of 50 deg south latitude for sea ice | North of 36 deg north latitude, south of 50 deg south latitude for sea ice |
| 40.2.3.2.2.2-2 | b. Measurement Range | 0 - 1, 0.1 increments | 0 - 1, 0.1 increments |
| 40.2.3.2.2.2-3 | c. Measurement Uncertainty | 0.1 | 0.1 |

## 40.2.4 *Sea Surface Temperature (SST)

Sea surface temperature (SST) is defined as the skin temperature of the ocean surface water. The measured radiances should enable the derivation of both skin and surface layer (1 meter depth) sea surface temperature to the specifications listed below, though an EDR algorithm is only required for skin temperature. The requirements below apply only under clear conditions.

Units: K

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| | **a. *Horizontal Cell Size** | | |
| 40.2.4-1 | 1. Global, at nadir | 3 km | 1 km |
| 40.2.4-2 | 2. Global, worst case | 4 km | (TBD) |
| 40.2.4-3 | **3. *Regional, at nadir** | **1 km** | 0.25 km |
| 40.2.4-4 | 4. Regional, worst case | 1.3 km | (TBD) |
| 40.2.4-5 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| | c. Horizontal Coverage | | |
| 40.2.4-6 | 1. Global | Oceans | Oceans |
| 40.2.4-7 | 2. Regional | Oceans, up to 1/2 orbit, non-contiguous, commandable by SOC | Oceans, up to 1/2 orbit, non-contiguous, commandable by SOC |
| 40.2.4-8 | d. Measurement Range | 271 K - 313 K | 271 K - 313 K |
| 40.2.4-9 | **e. *Measurement Uncertainty** | **0.5 K (TBR)** | 0.1 K |
| 40.2.4-10 | f. Measurement Accuracy | 0.2 K | 0.1 K |
| 40.2.4-11 | g. Measurement Precision | (TBD) | 0.1 K |
| | h. Mapping Uncertainty | | |
| 40.2.4-12 | 1. Global, at nadir | 1 km | 0.5 km |
| 40.2.4-13 | 2. Global, worst case | 3 km | (TBD) |
| 40.2.4-14 | 3. Regional, at nadir | 1 km | 0.1 km |
| 40.2.4-15 | 4. Regional, worst case | 3 km | (TBD) |
| 40.2.4-16 | i. Maximum Local Average Revisit Time | 6 hrs | 3 hrs |
| 40.2.4-17 | j. Maximum Local Refresh | (TBD) | (TBD) |

## 40.2.5 *Sea Surface Winds (Speed and Direction)

Atmospheric wind speed and direction at the sea/atmosphere interface. This parameter is to be reported at 19.5 meters above sea level.

Units:
Speed, m/s
Direction, degrees from geographic (true) north

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.2.5-1 | a. Horizontal Cell Size | 20 km | 1 km |
| 40.2.5-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.2.5-3 | c. Horizontal Coverage | Oceans | Oceans |
| | d. Measurement Range | | |
| 40.2.5-4 | 1. Speed | 3 - 25 m/s | 1 - 50 m/s |
| 40.2.5-5 | 2. Direction | 0 - 360 deg | 0 - 360 deg |
| | **e. *Measurement Accuracy** | | |
| 40.2.5-6 | **1. *Speed** | **2 m/s or 20 % of true value, whichever is greater** | 1 m/s or 10 % of true value, whichever is greater |
| 40.2.5-7 | 2. Direction | 20 deg for wind speeds greater than 8 m/s<br>45 deg (TBR) for wind speeds less than 8 m/s | 10 deg |
| | f. Measurement Precision | | |
| 40.2.5-8 | 1. Speed | 1 m/s | 1 m/s |
| 40.2.5-9 | 2. Direction | 10 deg | 10 deg |
| 40.2.5-10 | g. Mapping Uncertainty | 5 km | 1 km |
| 40.2.5-11 | h. Maximum Local Average Revisit Time | 6 hrs | 1 hrs |
| 40.2.5-12 | i. Maximum Local Refresh | (TBD) | (TBD) |

## 40.2.6 *Soil Moisture

Total water in all phases in the soil or in a surface layer over soil. The threshold requirement is to measure soil moisture only within a thin layer at the surface (0.1 cm thick) and only for bare soil in regions with known soil types. The objective is to measure a moisture profile for any soil, whether bare or not, and whether or not the soil type is known.

Units: cm/m (cm of water per meter of soil depth)

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| | a. Horizontal Cell Size | | |
| 40.2.6-1 | 1. Clear, at nadir (TBR) | 1 km | (TBD) |
| 40.2.6-2 | 2. Clear, worst case (TBR) | 4 km | 2 km |
| 40.2.6-3 | 3. Cloudy, at nadir | 40 km | 2 km |
| 40.2.6-4 | 4. Cloudy, worst case | 50 km | (TBD) |
| 40.2.6-5 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.2.6-6 | c. Vertical Cell Size | 0.1 cm | 5 cm |
| 40.2.6-7 | d. Vertical Reporting Interval | N/A (single value reported) | 5 cm |
| 40.2.6-8 | e. Horizontal Coverage | Land | Land |
| 40.2.6-9 | **f. *Vertical Coverage (TBR)** | **Surface to -0.1 cm (skin layer)** | Surface to -80 cm |
| 40.2.6-10 | g. Measurement Range | 0 - 100 cm/m (TBR) | 0 - 100 cm/m |
| | h. Measurement Uncertainty | | |
| 40.2.6-11 | 1. Clear, Bare soil in regions with known soil types (smaller horizontal cell size) | 10 cm/m (TBR) | Surface: 1 cm/m<br>Total 80 cm column: greater of 5 % or 0.013 cm/m (130 g/m$^3$) |
| 40.2.6-12 | 2. Cloudy , Bare soil in regions with known soil types (greater horizontal cell size) | 20 cm/m (TBR) | Surface: 1 cm/m<br>Total 80 cm column: greater of 5 % or 0.013 cm/m (130 g/m$^3$) |
| 40.2.6-13 | i. Mapping Uncertainty | 3 km | 1 km |
| 40.2.6-14 | j. Maximum Local Average Revisit Time | 8 hrs | 3 hrs |
| 40.2.6-15 | k. Maximum Local Refresh | (TBD) | (TBD) |

## 40.3 Atmospheric EDRs

### 40.3.1 Aerosols

Aerosols are defined as suspensions of liquid droplets or solid particles in the atmosphere. Aerosols include, but are not limited to, smoke, dust, sand, volcanic ash, sea spray, polar stratospheric clouds, and smog. Water and ice clouds are also aerosols, but because of the frequency of their occurrence and their importance to military operations, they are addressed separately in another EDR (See Sec. 40.2.3, Imagery).

#### 40.3.1.1 Aerosol Optical Thickness

Aerosol optical thickness (AOT), for this EDR, is defined as the extinction (scattering + absorption) vertical optical thickness of aerosols at multiple wavelengths within the 0.4 - 2.4 micron spectral range, including the midpoints of all narrow bands used to estimate the aerosol particle size parameter (see sec. 40.3.1.2). Optical thickness (..) is related to transmission (t) by t = exp (-..). The requirements below apply only under clear and daytime conditions.

Units: Dimensionless

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.3.1.1-1 | a. Horizontal Cell Size | 10 km | 1 km |
| 40.3.1.1-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.3.1.1-3 | c. Vertical Cell Size | 30 km (Total Column) | 50 km |
| 40.3.1.1-4 | 1. 0 - 2 km | N/A | 0.25 km |
| 40.3.1.1-5 | 2. 2 - 5 km | N/A | 0.5 km |
| 40.3.1.1-6 | 3. > 5 km | N/A | 1 km |
| 40.3.1.1-7 | d. Vertical Reporting Interval | N/A (Total Column) | Vertical cell size |
| 40.3.1.1-8 | e. Horizontal Coverage | Global | Global |
| 40.3.1.1-9 | f. Vertical Coverage | 0 - 30 km | 0 - 50 km |
| 40.3.1.1-10 | g. Measurement Range | 0 - 2 | 0 - 10 |
| | h. Measurement Accuracy | | |
| 40.3.1.1-11 | 1. Over Ocean | 0.03 | 0.01 |
| 40.3.1.1-12 | 2. Over Land | N/A | 0.1 |
| 40.3.1.1-13 | i. Measurement Precision | 0.03 | 0.01 |
| 40.3.1.1-14 | j. Long Term Stability | 0.01 | 0.003 |
| 40.3.1.1-15 | k. Mapping Uncertainty | 4 km | 1 km |
| 40.3.1.1-16 | l. Maximum Local Average Revisit Time | 6 hrs (TBR) | 4 hrs(TBR) |
| 40.3.1.1-17 | m. Maximum Local Refresh | (TBD) | (TBD) |

### 40.3.1.2 Aerosol Particle Size Parameter

Aerosol particle size may be characterized by two different parameters, the Ångström wavelength exponent and the effective radius. The Ångström wavelength exponent "alpha" (↦) is defined by:

$$\mapsto = - \delta \ln \tau / \delta \ln \lambda$$

where: "tau" (τ) is the extinction (scattering + absorption) vertical optical thickness of the aerosols within specified layers of the atmosphere, "lambda" (λ) is the wavelength, and "delta" (δ) refers to the difference between measurements in two narrow bands. The effective radius is the area weighted average radius of the aerosol particle size distribution or, equivalently, the ratio of the third to the second moments of the size distribution. The threshold requirement is to measure the Ångström wavelength exponent based on two different narrow wavelength bands (bandwidth ≤ 0.05 μm) within the 0.4 to 1.0 micron spectral range for which the midpoint wavelengths are separated by at least 0.2 μm, and meet the data content and quality requirements pertaining to this parameter in the threshold column of the table below. The objective is to measure the effective radius of the aerosol particle size distribution and meet the data content and quality objectives pertaining to this parameter given in the table below. The requirements below apply only under clear and daytime conditions.

Units: Ångström Wavelength Exponent: Dimensionless.
Effective Radius: μm

| Para. No. | | **Thresholds (Pertaining to Ångström wavelength exponent)** | **Objectives (Pertaining to effective radius)** |
|---|---|---|---|
| 40.3.1.2-1 | a. Horizontal Cell Size | 10 km | 1 km |
| 40.3.1.2-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.3.1.2-3 | c. Vertical Cell Size | 30 km (Total Column) | 50 km |
| 40.3.1.2-4 | 1. 0 - 2 km | N/A | 0.25 km |
| 40.3.1.2-5 | 2. 2 - 5 km | N/A | 0.5 km |
| 40.3.1.2-6 | 3. > 5 km | N/A | 1 km |
| 40.3.1.2-7 | d. Vertical Reporting Interval | N/A (Total Column) | Vertical cell size |
| 40.3.1.2-8 | e. Horizontal Coverage | Global | Global |
| 40.3.1.2-9 | f. Vertical Coverage | 0 - 30 km | 0 - 50 km |
| 40.3.1.2-10 | g. Measurement Range | -1 to +3 | 0.05 to 5 μm |
| 40.3.1.2-11 | h. Measurement Accuracy | 0.3 over ocean | 10 % |
| 40.3.1.2-12 | i. Measurement Precision | 0.3 | 10 % |
| 40.3.1.2-13 | j. Long Term Stability | 0.1 | 5 % |
| 40.3.1.2-14 | k. Mapping Uncertainty | 4 km | 1 km |
| 40.3.1.2-15 | l. Maximum Local Average Revisit Time | 6 hrs | 4 hrs(TBR) |
| 40.3.1.2-16 | m. Maximum Local Refresh | (TBD) | (TBD) |

### 40.3.1.3 Suspended Matter

As a threshold, the required content of this EDR is to report the presence of suspended matter such as dust, sand, volcanic ash, smoke, or radioactive material at any altitude. The objective is to report the presence of suspended matter in 0.2 km thick layers of the atmosphere, including sea salt. Other objectives are discriminating and classifying different types of suspended matter, for clearly delineated types, and reporting the concentrations of suspended matter types. Minimum detectable concentration levels for suspended matter types are not specified, and will be a by-product of capabilities required by other EDRs. The requirements below apply only under clear, daytime conditions.

Units:
Typing: N/A
Concentration: $\mp g/m^3$

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.3.1.3-1 | a. Horizontal Cell Size | 3 km | 1 km |
| 40.3.1.3-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.3.1.3-3 | c. Vertical Cell Size | 30 km (Total Column) | 0.2 km |
| 40.3.1.3-4 | d. Vertical Reporting Interval | N/A | Vertical Cell Size |
| 40.3.1.3-5 | e. Horizontal Coverage | Global | Global |
| 40.3.1.3-6 | f. Vertical Coverage | 0-30 km | (TBD) |
| | g. Measurement Range | | |
| 40.3.1.3-14 | 1. Detection | Flag cells where atmosphere contains suspended matter | Flag atmospheric layers containing suspended matter |
| 40.3.1.3-7 | 2. Type | N/A | Dust, sand, volcanic ash, sea salt, smoke, radioactive material, other |
| 40.3.1.3-8 | 3. Concentration | N/A | 0 - 100 $\mp g/m^3$ for smoke, other types (TBD) |
| 40.3.1.3-9 | h. Probability of Correct Typing | (TBD) for detection flag | (TBD) for classes |
| 40.3.1.3-10 | i. Measurement Uncertainty (concentration) | N/A | (TBD) |
| 40.3.1.3-11 | j. Mapping Uncertainty | 3 km | 0.1 km |
| 40.3.1.3-12 | k. Maximum Local Average Revisit Time | 12 hrs | 3 hrs |
| 40.3.1.3-13 | l. Maximum Local Refresh | (TBD) | (TBD) |

## 40.3.2 Ozone Total Column/Profile (DOC)

Ozone total column is defined as the amount of ozone in a vertical column of the atmosphere measured in Dobson Units (atm-cm). Ozone vertical profile is defined as the volumetric concentration of ozone in specified segments of a vertical column of the atmosphere measured in parts per million volume (ppmv). For this EDR, vertical cell size is the vertical height of the column segment and the vertical reporting interval specifies the locations of the column segment bottoms for which ozone parameters must be reported. Total Column requirements listed below apply under all cloud conditions. Profile threshold requirements apply down to the level of the tropopause.

Units:
Total column: milli-atm-cm
Profile: ppmv

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| | a. Horizontal Cell Size | | |
| 40.3.2-1 | 1. Total Column | 50 km @ nadir | 50 km |
| 40.3.2-2 | 2. Profile | 250 km | 250 km |
| 40.3.2-3 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| | c. Vertical Cell Size | | |
| 40.3.2-4 | 1. Total Column | 60 km | 60 km |
| 40.3.2-5 | 2. Profile, 0 - Tropopause | N/A | 3 km |
| 40.3.2-6 | 3. Profile, Tropopause - 25 km | 5 km | 1 km |
| 40.3.2-7 | 4. Profile, 25 - 60 km | 5 km | 3 km |
| | d. Vertical Reporting Interval | | |
| 40.3.2-8 | 1. Total Column | N/A | N/A |
| 40.3.2-9 | 2. Profile | Vertical Cell Size | Vertical Cell Size |
| 40.3.2-10 | e. Horizontal Coverage | Solar zenith angles < 80 degrees | Global |
| 40.3.2-11 | f. Vertical Coverage | | |
| 40.3.2-11a | 1. Total Column | 0 - 60 km | 0 - 60 km |
| 40.3.2-11b | 2. Profile | Tropopause -60 km | 0 - 60 km |
| | g. Measurement Range | | |
| 40.3.2-12 | 1. Total Column | 50 - 650 milli-atm-cm | 50 - 650 milli-atm-cm |
| 40.3.2-13 | 2. Profile, 0 - Tropopause | N/A | 0.01 - 3 ppmv |
| 40.3.2-14 | 3. Profile, Tropopause - 60 km | 0.1 - 15 ppmv | 0.1 - 15 ppmv |
| | h. Measurement Accuracy | | |
| 40.3.2-15 | 1. Total Column | 15 milli-atm-cm | 5 milli-atm-cm |
| 40.3.2-16 | 2. Profile, 0 - Tropopause | N/A | 10 % |
| 40.3.2-17 | 3. Profile, Tropopause - 15 km | **Greater of** 20 % or 0.1 ppmv | 10 % |
| 40.3.2-18 | 4. Profile, 15 - 60 km | **Greater of** 10 % or 0.05 ppmv | 5 % |
| | i. Measurement Precision | | |
| 40.3.2-19 | 1. Total Column | 3.0 milli-atm-cm + 0.5 % of measured ozone | 1 milli-atm-cm |
| 40.3.2-20 | 2. Profile, 0 - Tropopause | N/A | 10 % |
| 40.3.2-21 | 3. Profile, Tropopause - 15 km | 10 % | 3 % |
| 40.3.2-22 | 4. Profile, 15 - 50 km | 3 % | 1 % |
| 40.3.2-23 | 5. Profile, 50 - 60 km | 10 % | 3 % |
| | j. Long Term Stability | | |
| 40.3.2-24 | 1. Total Column | 1 % | 0.5 % |
| 40.3.2-25 | 2. Profile | 2 % | 1 % |
| | k. Mapping Uncertainty | | |
| 40.3.2-26 | 1. Total Column, at nadir | 5 km | 5 km |
| 40.3.2-27 | 2. Profile | 25 km | 25 km |
| | l. Maximum Local Average Revisit Time | | |
| 40.3.2-28 | 1. Total Column | 24 hrs | 24 hrs |
| 40.3.2-29 | 2. Profile | 7 days | 24 hrs |
| | m. Maximum Local Refresh | | |
| 40.3.2-30 | 1. Total Column | N/A | N/A |
| 40.3.2-31 | 2. Profile | N/A | N/A |

## 40.3.3 Precipitable Water

Precipitable water is defined as the total equivalent water in a vertical column of the atmosphere per unit cross-sectional area. The requirements below apply under both clear and cloudy conditions.

Units: mm of condensed vapor

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.3.3-1 | a. Horizontal Cell Size | 25 km (TBR) | 1 km |
| 40.3.3-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.3.3-3 | c. Horizontal Coverage | Global | Global |
| 40.3.3-4 | d. Measurement Range | 0 - 75 mm | 0 - 100 mm |
| 40.3.3-5 | e. Measurement Accuracy | Greater of 10 % or 2 mm | 1 mm |
| 40.3.3-6 | f. Measurement Precision | 1 mm | 1 mm |
| 40.3.3-7 | g. Mapping Uncertainty | 3 km | 0.1 km |
| 40.3.3-8 | h. Maximum Local Average Revisit Time | 6 hrs | 3 hrs |
| 40.3.3-9 | i. Maximum Local Refresh | (TBD) | (TBD) |

## 40.3.4 Precipitation (Type, Rate)

The required data products are precipitation rate and identification of type as rain or ice. Unless otherwise specified, the requirements in the table below apply to both precipitation type and rate and apply under both clear and cloudy conditions.

Units:
Rate: mm/hr
Type: rain, ice

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.3.4-1 | a. Horizontal Cell Size | 15 km | 0.1 km |
| 40.3.4-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.3.4-3 | c. Horizontal Coverage | Global | Global |
| | d. Measurement Range | | |
| 40.3.4-4 | 1. Precipitation Rate | 0 - 50(TBR) mm/hr | 0 - 250 mm/hr |
| 40.3.4-5 | 2. Precipitation Type | Rain and ice | Rain and ice |
| 40.3.4-6 | e. Measurement Accuracy, Precip. Rate | 2 mm/hr | 2 mm/hr |
| 40.3.4-7 | f. Measurement Precision, Precip. Rate | 1 mm/hr | 1 mm/hr |
| 40.3.4-8 | g. Correct Typing Probability, Precip. Type | (TBD) % | (TBD) % |
| 40.3.4-9 | h. Mapping Uncertainty | 3 km | 0.1 km |
| 40.3.4-10 | i. Maximum Local Average Revisit Time | 8 hrs (TBR) | 3 hrs |
| 40.3.4-11 | j. Maximum Local Refresh | (TBD) | (TBD) |

## 40.3.5 Pressure Profile(TBR)

A pressure profile is a set of estimates of the atmospheric pressure at specified altitudesabove the earth's surface. The requirements below apply under both clear and cloudy conditions.

Units: mb

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.3.5-1 | a. Horizontal Cell Size | 25 km | 5 km |
| 40.3.5-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.3.5-3 | c. Vertical Cell Size | 1 km | 0 km |
| | d. Vertical Reporting Interval | | |
| 40.3.5-4 | 1. 0 - 2 km | 1 km | 0.25 km |
| 40.3.5-5 | 2. 2 - 5 km | 1 km | 0.5 km |
| 40.3.5-6 | 3. > 5 km | 1 km | 1 km |
| 40.3.5-7 | e. Horizontal Coverage | Global | Global |
| 40.3.5-8 | f. Vertical Coverage | 0 - 30 km | 0 - 30 km |
| 40.3.5-9 | g. Measurement Range | 10 - 1050 mb | 10 - 1050 mb |
| | h. Measurement Accuracy | | |
| 40.3.5-10 | 1. 0 - 2 km | 1 % (TBR) | |
| 40.3.5-11 | 2. 2 - 10 km | **Greater of** 1 % or 10 mb | 3 % (TBR) |
| 40.3.5-12 | 3. 10 - 30 km | **Greater of** 1 % or 1 mb | 0.5 % |
| 40.3.5-13 | i. Measurement Precision | 4 mb | 2 mb |
| 40.3.5-14 | j. Mapping Uncertainty | 7 km | 1 km |
| 40.3.5-15 | k. Maximum Local Average Revisit Time | 12 hrs | 1 hr |
| 40.3.5-16 | l. Maximum Local Refresh | (TBD) | (TBD) |

## 40.3.6 Total Water Content

Total water content is defined as the water vapor, cloud liquid water, and cloud ice liquid equivalent in specified segments of a vertical column of the atmosphere. For this EDR, vertical cell size is the vertical height of the column segment and the vertical reporting interval specifies the locations of the column segment bottoms for which cloud liquid water must be reported. The requirements below apply under both clear and cloudy conditions.

Units: $kg/m^2$

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.3.6-1 | a. Horizontal Cell Size | 20 km | 10 km |
| 40.3.6-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.3.6-3 | c. Vertical Cell Size | 3 km (TBR) | 1 km |
| 40.3.6-4 | d. Vertical Reporting Interval | Vertical cell size | Vertical cell size |
| 40.3.6-5 | e. Horizontal Coverage | Global | Global, |
| 40.3.6-6 | f. Vertical Coverage | 0 - 20 km | 0 - (TBD) km |
| 40.3.6-7 | g. Measurement Range | 0-200 $kg/m^2$ (TBR) | (TBD) |
| | h. Measurement Uncertainty | | |
| 40.3.6-8 | 1. Point Measurement | 2 $kg/m^2$ | (TBD) |
| 40.3.6-9 | 2. Global Average | 1 $kg/m^2$ | (TBD) |
| 40.3.6-10 | i. Mapping Uncertainty | 7 km | 7 km |
| 40.3.6-11 | j. Maximum Local Average Revisit Time | 8 hrs | 3 hrs |
| 40.3.6-12 | k. Maximum Local Refresh | (TBD) | (TBD) |

## 40.4 Cloud EDRs

In this section "cloud" always means "detectable cloud" as defined in the glossary.

### 40.4.1 Cloud Base Height

Cloud base height is defined as the height above ground level where cloud bases occur. More precisely, for a cloud covered earth location, cloud base height is the set of altitudes of the bases of the clouds that intersect the local vertical at this location. The reported heights are horizontal spatial averages over a cell, i.e., a square region of the earth's surface. If a cloud layer does not extend over an entire cell, the spatial average is limited to the portion of the cell that is covered by the layer. As a threshold, only the height of the base of the lowest altitude cloud layer is required and the objective is to report cloud base height for all distinct cloud layers.

Units: km

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.4.1-1 | a. Horizontal Cell Size | 25 km | 10 km |
| 40.4.1-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.4.1-3 | c. Horizontal Coverage | Global | Global |
| | d. Vertical Cell Size | N/A | N/A |
| 40.4.1-4 | e. Vertical Reporting Interval | Base of lowest cloud layer | Base of all distinct cloud layers |
| 40.4.1-5 | f. Measurement Range | 0 - 15 km | 0 - 30 km |
| 40.4.1-6 | g. Measurement Uncertainty | 2 km (TBR) | 0.25 km |
| 40.4.1-7 | h. Mapping Uncertainty | 4 km | 1 km |
| 40.4.1-8 | i. Maximum Local Average Revisit Time | 6 hrs | 4 hrs |
| 40.4.1-9 | j. Maximum Local Refresh | (TBD) | (TBD) |

### 40.4.2 Cloud Cover/Layers

Cloud cover is defined (TBR) as the fraction of a given area on the earth's surface for which a locally normal line segment, extending between two given altitudes, intersects a cloud. As a threshold, cloud cover is required for up to four layers of the atmosphere between the surface and an altitude of 20 km. As an objective, cloud cover is required for contiguous, 0.1 km thick layers at 0.1 km increments in altitude, from the surface of the earth to an altitude of 30 km.

Units: Dimensionless

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.4.2-1 | a. Horizontal Cell Size | 25 km | 2 km |
| 40.4.2-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| | c. Vertical Cell Size | N/A | N/A |
| 40.4.2-3 | d. Vertical Reporting Interval | Up to 4 layers | 0.1 km |
| 40.4.2-4 | e. Horizontal Coverage | Global | Global |
| 40.4.2-5 | f. Vertical Coverage | 0 - 20 km | 0 - 30 km |
| 40.4.2-6 | g. Measurement Range | 0 - 1.0 | 0 - 1.0 |
| 40.4.2-7 | h. Measurement Accuracy | 0.1 | 0.05 |
| 40.4.2-8 | i. Measurement Precision | 0.15 | 0.025 |
| 40.4.2-9 | j. Mapping Uncertainty | 4 km | 1 km |
| 40.4.2-10 | k. Maximum Local Average Revisit Time | 6 hrs | 4 hrs |
| 40.4.2-11 | l. Maximum Local Refresh | (TBD) | (TBD) |

## 40.4.3 Cloud Effective Particle Size

Effective cloud particle size is defined as the ratio of the third moment of the drop size distribution to the second moment, averaged over a layer of air within a cloud.

Units: ∓m

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.4.3-1 | a. Horizontal Cell Size | 50 km | 10 km |
| 40.4.3-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.4.3-3 | c. Vertical Cell Size | Vertical Reporting Interval | Vertical Reporting Interval |
| 40.4.3-4 | d. Vertical Reporting Interval | 1.0 km(TBR) | 0.3 km |
| 40.4.3-5 | e. Horizontal Coverage | Global | Global |
| 40.4.3-6 | f. Vertical Coverage | 0 - 20 km | 0 - 30 km |
| 40.4.3-7 | g. Measurement Range | 0 - 50 ∓m | (TBD) |
| 40.4.3-8 | h. Measurement Accuracy | Greater of 10 % or 4 ∓m | Greater of 5 % or 2 ∓m |
| 40.4.3-9 | i. Measurement Precision | Greater of 5 % or 2 ∓m | 2 % |
| 40.4.3-10 | j. Long Term Stability | 2 % | 1 % |
| 40.4.3-11 | k. Mapping Uncertainty | 4 km | 1 km |
| 40.4.3-12 | l. Maximum Local Average Revisit Time | 8 hrs | 3 hrs |
| 40.4.3-13 | m. Maximum Local Refresh | (TBD) | (TBD) |

## 40.4.4 Cloud Ice Water Path (DOC)

Cloud ice water path is defined as the equivalent amount of water within cloud ice particles in a specified segment of a vertical column of the atmosphere. For this EDR, vertical cell size is the vertical height of the column segment and the vertical reporting interval specifies the locations of the column segment bottoms for which cloud ice water path must be reported.

Units: $kg/m^2$

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.4.4-1 | a. Horizontal Cell Size | 50 km | 10 km |
| 40.4.4-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.4.4-3 | c. Vertical Cell Size | 15 km (Total Column) | Vertical Reporting Interval |
| 40.4.4-4 | d. Vertical Reporting Interval | N/A (Total Column) | 0.3 km |
| 40.4.4-5 | e. Horizontal Coverage | Global | Global |
| 40.4.4-6 | f. Vertical Coverage | 0 - 20 km | 0 - 20 km |
| 40.4.4-7 | g. Measurement Range | 0 - 2.6 $kg/m^2$(TBR) | 0 - 10 $kg/m^2$ |
| 40.4.4-8 | h. Measurement Accuracy | **Greater of** 10 % or 5 $g/m^2$ (TBR) | 5 % |
| 40.4.4-9 | i. Measurement Precision | 5 % | 2 % |
| 40.4.4-10 | j. Long Term Stability | 2 % | 1 % |
| 40.4.4-11 | k. Mapping Uncertainty | 4 km | 1 km |
| 40.4.4-12 | l. Maximum Local Average Revisit Time | 6 hrs | 3 hrs |
| 40.4.4-13 | m. Maximum Local Refresh | (TBD) | (TBD) |

## 40.4.5 Cloud Liquid Water

Cloud liquid water is defined as the equivalent amount of water within cloud particles in a specified segment of a vertical column of the atmosphere. For this EDR, vertical cell size is the vertical height of the column segment and the vertical reporting interval specifies the locations of the column segment bottoms for which cloud liquid water must be reported.

Units: mm

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.4.5-1 | a. Horizontal Cell Size | 20 km | 5 km |
| 40.4.5-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.4.5-3 | c. Vertical Cell Size | 30 km (Total Column) | Vertical Reporting Interval |
| 40.4.5-4 | d. Vertical Reporting Interval | N/A (Total Column) | 0.3 km |
| 40.4.5-5 | e. Horizontal Coverage | Global | Global |
| 40.4.5-6 | f. Vertical Coverage | 0 - 20 km | 0 - 30 km |
| 40.4.5-7 | g. Measurement Range | 0 - 5 $kg/m^2$ | (TBD) |
| | h. Measurement Uncertainty | | |
| 40.4.5-8 | 1. Over ocean | 0.25 $kg/m^2$ | 0.01 $kg/m^2$ |
| 40.4.5-9 | 2. Over land | 0.5 $kg/m^2$ | 0.01 $kg/m^2$ |
| 40.4.5-10 | i. Mapping Uncertainty | 7 km | 1 km |
| 40.4.5-11 | j. Maximum Local Average Revisit Time | 8 hrs | 4 hrs |
| 40.4.5-12 | k. Maximum Local Refresh | (TBD) | (TBD) |

## 40.4.6 Cloud Optical Thickness (IORD Name: Cloud Optical Depth/Transmissivity)

Cloud optical thickness is defined as the extinction (scattering + absorption) vertical optical thickness of all cloud layers in a vertical column of the atmosphere. Optical thickness (..) is related to transmittance (t) by t= exp (-..). Optical thickness is wavelength dependent and is to be measured in at least two narrow bands centered at 450 nm (TBR) and 850 nm (TBR), with TBD nm bandwidth.

Units: Dimensionless

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.4.6-1 | a. Horizontal Cell Size | 50 km | 10 km |
| 40.4.6-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.4.6-3 | c. Horizontal Coverage | Global | Global |
| 40.4.6-4 | d. Measurement Range | 0 - 10 optical depth (TBR) | (TBD) |
| 40.4.6-5 | e. Measurement Accuracy | Greater of 10 % or 0.05 optical depth | Greater of 5 % or (TBD) |
| 40.4.6-6 | f. Measurement Precision | Greater of 5 % or 0.025 optical depth | Greater of 2 % or (TBD) |
| 40.4.6-7 | g. Long Term Stability | 2 % | 1 % |
| 40.4.6-8 | h. Mapping Uncertainty | 4 km | 1 km |
| 40.4.6-9 | i. Maximum Local Average Revisit Time | 8 hrs | 3 hrs |
| 40.4.6-10 | j. Maximum Local Refresh | (TBD) | (TBD) |

## 40.4.7 Cloud Top Height

Cloud top height is defined for each cloud-covered earth location as the set of heights of the tops of the cloud layers overlying the location. The reported heights are horizontal spatial averages over a cell, i.e., a square region of the earth's surface. If a cloud layer does not extend over an entire cell, the spatial average is limited to the portion of the cell that is covered by the layer. Cloud top height is not defined or reported for cells that are clear. As a threshold, only the height at the top of the highest altitude cloud layer is required. The objective is to report the cloud top height for all distinct cloud layers.

Units: km

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.4.7-1 | a. Horizontal Cell Size | 25 km | 10 km |
| 40.4.7-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.4.7-3 | c. Horizontal Coverage | Global | Global |
| | d. Vertical Cell Size | N/A | N/A |
| 40.4.7-4 | e. Vertical Reporting Interval | Top of highest cloud layer | Top of all distinct cloud layers |
| 40.4.7-5 | f. Measurement Range | 0-20 km | (TBD) |
| | g. Measurement Accuracy | | |
| 40.4.7-6 | 1. Cloud layer optical thickness > 0.1 (TBR) | 1.0 km (TBR) | 0.3 km |
| 40.4.7-7 | 2. Cloud layer optical thickness □ 0.1 (TBR) | 2 km | 0.3 km |
| 40.4.7-8 | h. Measurement Precision | 0.3 km | 0.15 km |
| 40.4.7-9 | i. Long Term Stability | 0.2 km | 0.1 km |
| 40.4.7-10 | j. Mapping Uncertainty | 4 km | 1 km |
| 40.4.7-11 | k. Maximum Local Average Revisit Time | 8 hrs | 6 hrs |
| 40.4.7-12 | l. Maximum Local Refresh | (TBD) | (TBD) |

## 40.4.8 Cloud Top Pressure (DOC)

Cloud top pressure is defined for each cloud-covered earth location as the set of atmospheric pressures at the tops of the cloud layers overlying the location. The reported pressures are horizontal spatial averages over a cell, i.e., a square region of the earth's surface. If a cloud layer does not extend over an entire cell, the spatial average is limited to the portion of the cell that is covered by the layer. Cloud top pressure is not defined or reported for cells that are clear. As a threshold, only the pressure at the top of the highest altitude cloud layer is required. The objective is to report the cloud top pressure for all distinct cloud layers.

Units: mb

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.4.8-1 | a. Horizontal Cell Size | 15 km | 10 km |
| 40.4.8-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.4.8-3 | c. Horizontal Coverage | Global | Global |
| 40.4.8-4 | d. Measurement Range | 50-1050 mb | (TBD) |
| | e. Measurement Accuracy | | |
| 40.4.8-5 | 1. Surface - 3 km | 100 mb | 30 mb |
| 40.4.8-6 | 2. 3 - 7 km | 75 mb | 22 mb |
| 40.4.8-7 | 3. > 7 km | 50 mb | 15 mb |
| | f. Measurement Precision | | |
| 40.4.8-8 | 1. Surface - 3 km | 50 mb | 10 mb |
| 40.4.8-9 | 2. 3 - 7 km | 38 mb | 7 mb |
| 40.4.8-10 | 3. > 7 km | 25 mb | 5 mb |
| | g. Long Term Stability (TBR) | | |
| 40.4.8-11 | 1. Surface - 3 km | 10 mb | 3 mb |
| 40.4.8-12 | 2. 3 - 7 km | 7 mb | 2 mb |
| 40.4.8-13 | 3. > 7 km | 5 mb | 1 mb |
| 40.4.8-14 | h. Mapping Uncertainty | 4 km | 1 km |
| 40.4.8-15 | i. Maximum Local Average Revisit Time | 8 hrs | 3 hrs |
| 40.4.8-16 | j. Maximum Local Refresh | (TBD) | (TBD) |

## 40.4.9 Cloud Top Temperature

Cloud top temperature is defined for each cloud-covered earth location as the set of atmospheric temperatures at the tops of the cloud layers overlying the location. The reported temperatures are horizontal spatial averages over a cell, i.e., a square region of the earth's surface. If a cloud layer does not extend over an entire cell, the spatial average is limited to the portion of the cell that is covered by the layer. Cloud top temperature is not defined or reported for cells that are clear. As a threshold, only the temperature at the top of the highest altitude cloud layer is required. The objective is to report the cloud top temperature for all distinct cloud layers.

Units: K

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.4.9-1 | a. Horizontal Cell Size | 25 km | 10 km |
| 40.4.9-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.4.9-3 | c. Horizontal Coverage | Global | Global |
| 40.4.9-4 | d. Measurement Range | 180-310 K | (TBD) |
| | e. Measurement Accuracy | | |
| 40.4.9-5 | 1. Cloud layer optical thickness > 0.1 (TBR) | 3 K | 1.5 K |
| 40.4.9-6 | 2. Cloud layer optical thickness □ 0.1 (TBR) | 6 K | (TBD) |
| 40.4.9-7 | f. Measurement Precision | 1.5 K | 0.5 K |
| 40.4.9-8 | g. Long Term Stability | 1 K | 0.1 K |
| 40.4.9-9 | h. Mapping Uncertainty | 4 km | 1 km |
| 40.4.9-10 | i. Maximum Local Average Revisit Time | 6 hrs | 6 hrs |
| 40.4.9-11 | j. Maximum Local Refresh | (TBD) | (TBD) |

## 40.5 Earth Radiation Budget EDRs

All requirements for Earth Radiation Budget EDRs below apply only under both clear and cloudy conditions except for the Surface Albedo.

### 40.5.1 Absorbed Solar Radiation (IORD Name: Net Short-wave Radiation) (DOC)

Absorbed solar radiation is the difference between the incoming solar radiation flux (all wavelengths) at the top of the atmosphere and the outgoing reflected flux (all wavelengths) at the top of the atmosphere. This parameter is sometimes called "net short-wave radiation (TOA)" since solar radiation is mainly contained in the 0.3 - 4 μm band. This is an instantaneous, not a time-averaged, measurement. (TBR)

Units: $W/m^2$

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.5.1-1 | a. Horizontal Cell Size | 100 km | 20 km |
| 40.5.1-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.5.1-3 | c. Horizontal Coverage | Global | Global |
| 40.5.1-4 | d. Measurement Range | 0 - 900 $W/m^2$ | 0 - 900 $W/m^2$ |
| 40.5.1-5 | e. Measurement Accuracy | 5 $W/m^2$ | 2.5 $W/m^2$ |
| 40.5.1-6 | f. Measurement Precision | 3 $W/m^2$ | 1.5 $W/m^2$ |
| 40.5.1-7 | g. Mapping Uncertainty | 10 km | 5 km |
| 40.5.1-8 | h. Maximum Local Average Revisit Time | 12 hrs | 8 hrs |
| 40.5.1-9 | i. Maximum Local Refresh | (TBD) | (TBD) |

### 40.5.2 Albedo (Surface)

Surface albedo is defined as the amount of solar radiation reflected by the earth's surface into a hemisphere divided by the amount incident.(TBR) This EDR is required during daytime only and under clear conditions only. This is an instantaneous, not a time-averaged, measurement. (TBR)

Units: Dimensionless

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.5.2-1 | a. Horizontal Cell Size | 4 km | 0.5 km |
| 40.5.2-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.5.2-3 | c. Horizontal Coverage | Global | Global |
| 40.5.2-4 | d. Measurement Range | 0 - 1.0 | 0 - 1.0 |
| 40.5.2-5 | e. Measurement Accuracy | 0.05 | 0.0125 |
| 40.5.2-6 | f. Measurement Precision | 0.02 | 0.01 |
| 40.5.2-7 | g. Long Term Stability | 0.02 | 0.01 |
| 40.5.2-8 | h. Mapping Uncertainty | 4 km | 1.0 km |
| 40.5.2-9 | i. Maximum Local Average Revisit Time | 24 hrs | 4 hrs |
| 40.5.2-10 | j. Maximum Local Refresh | (TBD) | (TBD) |

## 40.5.3 Downward Long-wave Radiation (Surface) (DOC)

Downward long-wave radiation (surface) is defined as the irradiance in the 4 - 50 µm wavelength band incident downward at the surface of the earth. Physical measurements are not required in the entire 4 - 50 µm band as long as the reported value meets the accuracy requirement specified below. This is an instantaneous, not a time-averaged, measurement. (TBR)

Units: $W/m^2$

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.5.3-1 | a. Horizontal Cell Size | 40 km @ nadir | 10 km |
| 40.5.3-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.5.3-3 | c. Horizontal Coverage | Global | Global |
| 40.5.3-4 | d. Measurement Range | 0 - 500 $W/m^2$ | 0 - 500 $W/m^2$ |
| 40.5.3-5 | e. Measurement Accuracy | 15 $W/m^2$ (TBR) | 1 $W/m^2$ |
| 40.5.3-6 | f. Measurement Precision | 0.1 $W/m^2$ | 0.1 $W/m^2$ |
| 40.5.3-7 | g. Mapping Uncertainty | 10 km | (TBD) |
| 40.5.3-8 | h. Maximum Local Average Revisit Time | 14 hrs | 6 hrs |
| 40.5.3-9 | i. Maximum Local Refresh | (TBD) | (TBD) |

## 40.5.4 Downward Short-wave Radiation (Surface) (IORD Name: Insolation) (DOC)

Downward short-wave radiation (surface) is defined as the irradiance at wavelengths less than 4 µm incident downward at the surface of the earth. This is an instantaneous, not a time-averaged, measurement. (TBR)

Units: $W/m^2$

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.5.4-1 | a. Horizontal Cell Size | 50 km | 100 km (TBR) |
| 40.5.4-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.5.4-3 | c. Horizontal Coverage | Global | Global |
| 40.5.4-4 | d. Measurement Range | 0 - 1400 $W/m^2$ | 0 - 1400 $W/m^2$ |
| 40.5.4-5 | e. Measurement Accuracy | 20 $W/m^2$ | 1 $W/m^2$ |
| 40.5.4-6 | f. Measurement Precision | 5 $W/m^2$ | 0.1 $W/m^2$ |
| 40.5.4-7 | g. Mapping Uncertainty | 5 km | 1 km |
| 40.5.4-8 | h. Maximum Local Average Revisit Time | 24 hrs | 24 hrs |
| 40.5.4-9 | i. Maximum Local Refresh | (TBD) | (TBD) |

## 40.5.5 Outgoing Long-wave Radiation (Top of Atmosphere) (IORD Name: Total Long-wave Radiation) (DOC)

Outgoing long-wave radiation (top of atmosphere - TOA) is defined as the outgoing (upward) flux of long-wave radiation (4 - 50 µm) at the top of the atmosphere. This is an instantaneous, not a time-averaged, measurement. (TBR)

Units: $W/m^2$

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.5.5-1 | a. Horizontal Cell Size | 100 km | 20 km |
| 40.5.5-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.5.5-3 | c. Horizontal Coverage | Global | Global |
| 40.5.5-4 | d. Measurement Range | 0 - 500 $W/m^2$ | 0 - 500 $W/m^2$ |
| 40.5.5-5 | e. Measurement Accuracy | 5 $W/m^2$ | 2.5 $W/m^2$ |
| 40.5.5-6 | f. Measurement Precision | 3 $W/m^2$ | 1.5 $W/m^2$ |
| 40.5.5-7 | g. Mapping Uncertainty | 10 km | 5 km |
| 40.5.5-8 | h. Maximum Local Average Revisit Time | 24 hours (once/daytime & once/nighttime) | 4 hr |
| 40.5.5-9 | i. Maximum Local Refresh | (TBD) | (TBD) |

## 40.5.6 Solar Irradiance (DOC)

Solar irradiance is the radiated power incident on a surface orthogonal to the line of sight to the sun from the location of the spacecraft. The total irradiance (all wavelengths) and the irradiance in two narrow bands, one in the visible spectrum (0.2 - 0.3 µm) and one in the near infrared (centered at 1.5 µm), are to be reported.

Units: $W/m^2$

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| | a. Measurement Range | | |
| 40.5.6-1 | 1. Total | 1320 - 1420 $W/m^2$ | 1320 - 1420 $W/m^2$ |
| 40.5.6-2 | 2. 0.2 - 0.3 µm | 0 - 10 $W/m^2$ | 0 - 10 $W/m^2$ |
| 40.5.6-3 | 3. 1.5 µm narrow band | 0 - 10 $W/m^2$ | 0 - 10 $W/m^2$ |
| | b. Measurement Uncertainty (TBR) | | |
| 40.5.6-4 | 1. Total | 1.5 $W/m^2$ | 0.5 $W/m^2$ |
| 40.5.6-5 | 2. 0.2 - 0.3 µm | 2 % | 0.5 % |
| 40.5.6-6 | 3. 1.5 µm narrow band | 2 % | 0.5 % |
| | c. Long Term Stability (TBR) | | |
| 40.5.6-7 | 1. Total | 0.002 %/yr | 0.0005 %/yr |
| 40.5.6-8 | 2. 0.2 - 0.3 µm | 0.02 %/yr | 0.01 %/yr |
| 40.5.6-9 | 3. 1.5 µm narrow band | 0.01 %/yr | 0.005 %/yr |
| 40.5.6-10 | d. Reporting Frequency | 20 min of viewing sun per orbit, one satellite | 20 min of viewing sun per orbit, for each of three satellites |

## 40.6 Land EDRs

### 40.6.1 Land Surface Temperature

Land surface temperature (LST) is defined as the skin temperature of the uppermost layer of the land surface. This EDR is required under clear conditions only.

Units: K

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.6.1-1 | a. Horizontal Cell Size | 4 km | 1 km |
| 40.6.1-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.6.1-3 | c. Horizontal Coverage | Land | Land |
| 40.6.1-4 | d. Measurement Range | 213 K - 343 K | 213 K - 343 K |
| 40.6.1-5 | e. Measurement Accuracy | 2.5 K | 1 K |
| 40.6.1-6 | f. Measurement Precision | 0.5 K | 0.025 K |
| 40.6.1-7 | g. Mapping Uncertainty | 4 km | 1 km |
| 40.6.1-8 | h. Maximum Local Average Revisit Time | 6 hrs | 3 hrs |
| 40.6.1-9 | i. Maximum Local Refresh | (TBD) | (TBD) |

### 40.6.2 Normalized Difference Vegetation Index (NDVI) (TBR)

Normalized difference vegetation index is most directly related to absorption of photosynthetically active radiation, but is often correlated with biomass or primary productivity. Red spectral measurements are sensitive to the chlorophyll content of vegetation and the near IR to the mesophyll structure of leaves. The normalized ratio (IR-Red)/(IR+ Red) has a close relationship with the photosynthetic capacity of specific vegetation types.

The NASA/NOAA NDVI (for AVHRR-3) is defined as follows:

NDVI = RATIO of [(Reflectance band 2 - reflectance band 1)/ sum],
where: Band 2 = NIR band (0.72-1.0 microns);
Band 1 = VIS band (0.572-0.703 microns).

These specific spectral ranges are not required. The requirements below apply only under clear conditions.

Units: Dimensionless

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.6.2-1 | a. Horizontal Cell Size | 4 km | 1 km |
| 40.6.2-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.6.2-3 | c. Horizontal Coverage | Land | (TBD) |
| 40.6.2-4 | d. Measurement Range | -1 to +1 NDVI units | -1 to +1 NDVI units |
| 40.6.2-5 | e. Measurement Accuracy | 0.05 NDVI units | 0.03 NDVI units |
| 40.6.2-6 | f. Measurement Precision | 0.04 NDVI units | 0.02 NDVI units |
| 40.6.2-7 | g. Long Term Stability | 0.04 NDVI units | 0.04 NDVI units |
| 40.6.2-8 | h. Mapping Uncertainty | 4 km | 1 km |
| 40.6.2-9 | i. Maximum Local Average Revisit Time | 24 hrs | 24 hrs |
| 40.6.2-10 | j. Maximum Local Refresh | (TBD) | (TBD) |

## 40.6.3 Snow Cover/Depth

Horizontal and vertical extent of snow cover. As a threshold, only fraction of snow cover in the specified horizontal cell (clear or cloudy) is required, regardless of depth. As an objective, fraction of snow cover for snow having a specified minimum depth is required in the specified horizontal cell (clear or cloudy) for a set of specified minimum depths.

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| | a. Horizontal Cell Size (TBR) | | |
| 40.6.3-1 | 1. Clear - daytime | 1.3 km | 1 km |
| 40.6.3-2 | 2. Cloudy and/or nighttime | 12.5 km | 1 km |
| 40.6.3-3 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.6.3-4 | c. Snow Depth Ranges | > 0 cm (Any snow thickness) | > 8 cm, > 15 cm, > 30 cm, >51 cm, >76 cm |
| 40.6.3-5 | d. Horizontal Coverage | Land | Land & Ice |
| 40.6.3-6 | e. Vertical Coverage | 0 - 40 cm | 0 - 1 m |
| 40.6.3-7 | f. Measurement Range | 0 - 1 | 0 - 1 per snow depth category |
| | g. Measurement Uncertainty(TBR) | | |
| 40.6.3-8 | 1. Clear - daytime | 10 % (snow/no snow) | 10 % for snow depth |
| 40.6.3-9 | 2. Cloudy and/or nighttime | 20 % (snow/no snow) | (TBD) |
| | h. Mapping Uncertainty | | |
| 40.6.3-10 | 1. Clear | 2 km | 1 km |
| 40.6.3-11 | 2. Cloudy | 7 km | 1 km |
| 40.6.3-12 | i. Maximum Local Average Revisit Time | 12 hrs | 3 hrs |
| 40.6.3-13 | j. Maximum Local Refresh | (TBD) | (TBD) |

## 40.6.4 Vegetation Index/Surface Type

Vegetation index/surface type is defined as the predominant vegetation and/or soil type in a given area. Each given area shall be classified as one of the following 21 types: crop land, brush/scrub, coniferous forest, deciduous forest, tropical forest, grass land, swamp, marsh/bog, flooded land, loam, sandy soil, clay, peat, gravel, desert, water, snow/ice, urban/developed, rocky fields, tundra, and savannah. Estimation of the percentage of vegetation cover per type in each cell is an objective. The requirements below apply under both clear and cloudy conditions.

Units:
Type: N/A
Vegetation Cover: per cent

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| | a. Horizontal Cell Size | | |
| 40.6.4-1 | 1. Global | 20 km | 1 km |
| 40.6.4-2 | 2. Regional | 20 km | 0.25 km |
| 40.6.4-3 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| | c. Horizontal Coverage | | |
| 40.6.4-4 | 1. Global | Land | Land |
| 40.6.4-5 | 2. Regional | Land, up to 1/2 orbit, non-contiguous, commandable by SOC | Land, up to 1/2 orbit, non-contiguous, commandable by SOC |
| | d. Measurement Range | | |
| 40.6.4-6 | 1. Vegetation/surface type | 21 types specified above | 21 types specified above |
| 40.6.4-7 | 2. Vegetation cover | N/A | 0 - 100 % |
| 40.6.4-8 | e. Measurement Accuracy (veg. cover) | N/A | 2 % |
| 40.6.4-9 | f. Measurement Precision (veg. cover) | N/A | 0.1 % |
| 40.6.4-10 | g. Correct Typing Probability (vegetation /surface type) | 70 % | (TBD) |
| 40.6.4-11 | h. Mapping Uncertainty | 5 km | 1 km |
| 40.6.4-12 | i. Maximum Local Average Revisit Time | 24 hrs | 3 hrs |
| 40.6.4-13 | j. Maximum Local Refresh | (TBD) | (TBD) |

## 40.7 Ocean/Water EDRs

### 40.7.1 Currents (DoD-Coastal; DOC-Surface)

Ocean currents are defined as large-scale movements of the surface and near-surface waters of the ocean driven by wind and the distribution of water density. Currents are described by a local vector field specifying water speed and direction at each point. "Coastal" is defined to be within 370km of the coastline. The requirements below apply only under clear conditions.

Units:
Speed: m/s
Direction: deg from north

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| | a. Horizontal Cell Size | | |
| 40.7.1-1 | 1. Global | 4 km | 1 km |
| 40.7.1-2 | 2. Regional (Coastal) | 1.3 km | 0.25 km |
| 40.7.1-3 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.7.1-4 | c. Vertical Cell Size(TBR) | 5 m | 1 m |
| 40.7.1-5 | d. Vertical Reporting Interval | Vertical Cell Size | Vertical Cell Size |
| | e. Horizontal Coverage | Oceans | Oceans |
| 40.7.1-6 | 1. Global | Oceans, > 370 km from coastline | Oceans, > 370 km from coastline |
| 40.7.1-7 | 2. Regional (Coastal) | Oceans, < 370 km from coastline | Oceans, < 370 km from coastline |
| 40.7.1-8 | f. Vertical Coverage | 0 to -10 m | 0 to -30 m |
| | g. Measurement Range | | |
| 40.7.1-9 | 1. Speed | 0 - 5 m/s | 0 - 5 m/s |
| 40.7.1-10 | 2. Direction | 0 - 360 deg | 0 - 360 deg |
| | h. Measurement Accuracy(TBR) | | |
| 40.7.1-11 | 1. Speed | 0.25 m/s | 0.1 m/s |
| 40.7.1-12 | 2. Direction | 15 deg | 5 deg |
| | i. Measurement Precision(TBR) | | |
| 40.7.1-13 | 1. Speed | 0.25 m/s | 0.1 m/s |
| 40.7.1-14 | 2. Direction | 15 deg | 5 deg |
| 40.7.1-15 | j. Mapping Uncertainty | 3 km | 1 km |
| 40.7.1-16 | k. Maximum Local Average Revisit Time | (TBD) | 12 hrs |
| 40.7.1-17 | l. Maximum Local Refresh | (TBD) | (TBD) |

## 40.7.2 Fresh Water Ice

Fresh water ice concentration is defined as the fraction of a given area of fresh water that is covered by ice, quantized to the nearest one tenth. Ice edge boundary is the contour separating fresh water from fresh water ice. The error in ice edge boundary location is defined as the distance between a measured boundary point and the nearest point on the true ice edge boundary. The measurement uncertainty requirement on ice edge boundary limits this error. Ice edge concentration and boundaries are derived from the Imagery EDR. The requirements below apply only under clear conditions.

Units:
Concentration: Dimensionless
Ice Edge Boundary: lat/long

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| | a. Horizontal Cell Size | | |
| 40.7.2-1 | 1. Regional, nadir | 4 times 0.4 km (TBR) | (TBD) |
| 40.7.2-2 | 2. Regional, worst case | 4 times 0.8 km (TBR) | 4 times 0.65 km (TBR) |
| 40.7.2-3 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.7.2-4 | c. Horizontal Coverage | Fresh Water<br>Up to 1/2 orbit, non-contiguous, commandable by SOC | Fresh Water<br>Up to 1/2 orbit, non-contiguous, commandable by SOC |
| 40.7.2-5 | d. Measurement Range | 1/10 to 10/10 concentration | 0/10 to 10/10 concentration |
| | e. Measurement Uncertainty | | |
| 40.7.2-6 | 1. Ice Edge Boundary(TBS) | 10 km | 5 km |
| 40.7.2-7 | 2. Ice Concentration | **Greater of** 20 % or 1/10 | 10 % |
| 40.7.2-8 | f. Mapping Uncertainty | 3 km | 1 km |
| 40.7.2-9 | g. Maximum Local Average Revisit Time | 12hrs | 6hrs |
| 40.7.2-10 | h. Maximum Local Refresh | (TBD) | (TBD) |

## 40.7.3 Ice Surface Temperature

As a threshold, the temperature of the surface of ice over land or water is required. The objective is to measure the atmospheric temperature 2 m above the surface of the ice. This EDR is required under clear conditions only.
Units: K

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.7.3-1 | a. Horizontal Cell Size | 30 km | 10 km |
| 40.7.3-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.7.3-3 | c. Horizontal Coverage | Ice-covered land/water | Ice-covered land/water |
| 40.7.3-4 | d. Measurement Range | 213 K - 275 K (ice surface) | 213 K - 293 K (2 m above ice) |
| 40.7.3-5 | e. Measurement Uncertainty | 1 K | (TBD) |
| 40.7.3-6 | f. Mapping Uncertainty | 3 km | 1 km |
| 40.7.3-7 | g. Maximum Local Average Revisit Time | 24 hrs | 12 hrs |
| 40.7.3-8 | h. Maximum Local Refresh | (TBD) | (TBD) |

## 40.7.4 Littoral Sediment Transport

Littoral sediment transport is defined as the transport of sediment by river systems and along shore ocean currents. More specifically, for each cell on the earth's surface overlying water-covered sediment, littoral sediment transport is defined as the change in the volume of sediment in the cell since the last measurement, divided by the time interval between measurements. This EDR is required under clear and daytime conditions only.

Units: $m^3$/day

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.7.4-1 | a. Horizontal Cell Size | 1.3 km (TBR) | 0.1 km (TBR) |
| 40.7.4-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.7.4-3 | c. Horizontal Coverage | Rivers, ocean coastal regions | Rivers, ocean coastal regions |
| 40.7.4-4 | d. Measurement Range | (TBD) | (TBD) |
| 40.7.4-5 | e. Measurement Accuracy | Greater of 30 % or (TBD) | Greater of 15 % or (TBD) |
| 40.7.4-6 | f. Measurement Precision | Greater of 40 % or (TBD) | Greater of 15 % or (TBD) |
| 40.7.4-7 | g. Mapping Uncertainty | 3 km | 0.1 km |
| 40.7.4-8 | h. Maximum Local Average Revisit Time | 48 hrs | 12 hrs |
| 40.7.4-9 | i. Maximum Local Refresh | (TBD) | (TBD) |

## 40.7.5 Net Heat Flux

Net heat flux refers to net surface flux over oceans. Components are long-wave and short-wave radiation, latent heat flux and sensible heat flux. The requirements below apply under clear conditions only.

Units: $W/m^2$

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.7.5-1 | a. Horizontal Cell Size | 20 km | 5 km |
| 40.7.5-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.7.5-3 | c. Horizontal Coverage | Oceans (Includes ice covered) | Global |
| 40.7.5-4 | d. Measurement Range | 0 - 1000 $W/m^2$ | 0 - 2000 $W/m^2$ |
| 40.7.5-5 | e. Measurement Accuracy | 10 $W/m^2$ | 1 $W/m^2$ |
| 40.7.5-6 | f. Measurement Precision | 5 $W/m^2$ | 1 $W/m^2$ |
| 40.7.5-7 | g. Mapping Uncertainty | 7 km | (TBD) |
| 40.7.5-8 | h. Maximum Local Average Revisit Time | 6 hrs | 3 hrs |
| 40.7.5-9 | i. Maximum Local Refresh | (TBD) | (TBD) |

## 40.7.6 Ocean Color/Chlorophyll

The required data product is the concentration of chlorophyll in a vertical column of the ocean, and the requirements below apply to this product. Ocean color, as measured by the radiance reflected by the ocean in a number of narrow visible bands, is typically used to infer chlorophyll concentration. This EDR is required under clear, daytime conditions only.

Units: $mg/m^3$

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| | a. Horizontal Cell Size | | |
| 40.7.6-1 | 1. Global, worst case | 2.6 km | 1 km |
| 40.7.6-2 | 2. Regional (Coastal), worst case | 1.3 km | 0.1 km |
| 40.7.6-3 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| | c. Horizontal Coverage | Oceans | Oceans |
| 40.7.6-4 | 1. Global | > 370 km from coastline | > 370 km from coastline |
| 40.7.6-5 | 2. Regional (Coastal) | < 370 km from coastline | < 370 km from coastline |
| 40.7.6-6 | d. Measurement Range | 0.05 - 50 $mg/m^3$ | 0 - 100 $mg/m^3$ |
| 40.7.6-7 | e. Measurement Accuracy | Greater of 30 % or TBD $mg/m^3$ | Greater of 30 % or TBD $mg/m^3$ |
| 40.7.6-8 | f. Measurement Precision | Greater of 20 % or TBD $mg/m^3$ | Greater of 10 % or TBD $mg/m^3$ |
| | g. Mapping Uncertainty | | |
| 40.7.6-9 | 1. Global | 3 km | 0.5 km |
| 40.7.6-10 | 2. Regional | 3 km | 0.1 km |
| 40.7.6-11 | h. Maximum Local Average Revisit Time | 48 hrs | 12 hrs |
| 40.7.6-12 | i. Maximum Local Refresh | (TBD) | (TBD) |

## 40.7.7 Ocean Wave Characteristics (TBR)

Ocean wave characteristics are defined as the significant wave height and direction of ocean waves. The requirements below apply under both clear and cloudy conditions.

Units:
Height: m
Direction: Degrees from north

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| | a. Horizontal Cell Size | | |
| 40.7.7-1 | 1. Global, at nadir, along track | 20 km | 5 km |
| 40.7.7-2 | 2. Global, at nadir, cross track | 20 km | (TBD) |
| 40.7.7-3 | 3. Regional, at nadir, along track | 10 km | 0.25 km |
| 40.7.7-4 | 4. Regional, at nadir, cross track | (TBD) | (TBD) |
| 40.7.7-5 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.7.7-6 | c. Horizontal Coverage | Oceans | Oceans |
| | d. Measurement Range | | |
| 40.7.7-7 | 1. Height | 0.5 - 30 m | 0.5 - 30 m |
| 40.7.7-8 | 2. Direction | 0 - 360 deg | 0 - 360 deg |
| | e. Measurement Accuracy | | |
| 40.7.7-9 | 1. Height | 0.2 m | 0.2 m |
| 40.7.7-10 | 2. Direction | 10 deg | 5 deg |
| | f. Measurement Precision | | |
| 40.7.7-11 | 1. Height | 0.2 m | 0.1 m |
| 40.7.7-12 | 2. Direction | 10 deg | 5 deg |
| | g. Mapping Uncertainty | | |
| 40.7.7-13 | 1. Global, worst case | 10 km | 2 km |
| 40.7.7-14 | 2. Regional, worst case | 4 km | 0.25 km |
| 40.7.7-15 | h. Maximum Local Average Revisit Time | 14 days | 6 hrs |
| 40.7.7-16 | i. Maximum Local Refresh | (TBD) | (TBD) |

## 40.7.8 Sea Ice Age and Sea Ice Edge Motion

Sea ice age is defined as the time that has passed since the formation of the surface layer of an ice covered region of the ocean. The content of the sea ice age EDR is the typing of areas of sea ice by age. Sea ice motion is defined as the displacement of a sea ice edge. The requirements below apply under both clear and cloudy conditions.

Units:
Ice age: Class
Ice edge motion: km/day

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.7.8-1 | a. Horizontal Cell Size (Ice Age) | 3 km | 0.1 km |
| 40.7.8-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.7.8-3 | c. Horizontal Coverage | Oceans | Oceans |
| | d. Measurement Range | | |
| 40.7.8-4 | 1. Ice Age Classes | First Year, Multiyear (TBR) | New, Young, First Year, and Old (TBR) |
| 40.7.8-5 | 2. Ice Motion | 0-50 km/day | 0 - 50 km/day |
| 40.7.8-6 | e. Probability of Correct Typing (Ice Age) | 70 % | 90 % |
| 40.7.8-7 | f. Measurement Uncertainty (Ice motion) | 1 km/day | 0.1 km/day |
| 40.7.8-8 | g. Mapping Uncertainty | 3 km | 1 km |
| 40.7.8-9 | h. Maximum Local Average Revisit Time | 24 hrs | 12 hrs |
| 40.7.8-10 | i. Maximum Local Refresh | (TBD) | (TBD) |

## 40.7.9 Sea Surface Height

Sea surface height is defined as the long-wave (> (TBD) km) horizontal variations in the height of the sea surface with respect to the geoid. The requirements below apply under both clear and cloudy conditions.

Units: m

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.7.9-1 | a. Horizontal Cell Size (at nadir along track) | 10 km | 0.5 km |
| 40.7.9-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.7.9-3 | c. Horizontal Coverage | Oceans | Oceans |
| 40.7.9-4 | d. Measurement Range | -50 to +50 m | -50 to +50 m |
| 40.7.9-5 | e. Measurement Accuracy | 5 cm | 3 cm |
| 40.7.9-6 | f. Measurement Precision | 3 cm | 2 cm |
| 40.7.9-7 | g. Mapping Uncertainty | 2 km | 1 km |
| 40.7.9-8 | h. Maximum Local Average Revisit Time | 14 days | 3 hr |
| 40.7.9-9 | i. Maximum Local Refresh | (TBD) | (TBD) |

## 40.7.10 Surface Wind Stress (DOC) (TBR)

Surface wind stress is defined as magnitude of the frictional stress of the wind acting on the sea surface, causing it to move as a wind-drift current, and causing the formation of waves. The requirements below apply under both clear and cloudy conditions.

Units: $N/m^2$

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.7.10-1 | a. Horizontal Cell Size | 50 km | 20 km |
| 40.7.10-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.7.10-3 | c. Horizontal Coverage | Oceans | Oceans |
| 40.7.10-4 | d. Measurement Range | 0 - 50 $N/m^2$ (TBR) | 0 - 50 $N/m^2$ |
| 40.7.10-5 | e. Measurement Accuracy | 2 $N/m^2$ | 1 $N/m^2$ |
| 40.7.10-6 | f. Measurement Precision | 2 $N/m^2$ | 1 $N/m^2$ |
| 40.7.10-7 | g. Mapping Uncertainty | 7 km | 1 km |
| 40.7.10-8 | h. Maximum Local Average Revisit Time | 12 hrs | 12 hr |
| 40.7.10-9 | i. Maximum Local Refresh | (TBD) | (TBD) |

## 40.7.11 Mass Loading (TBR) (IORD Name: Turbidity)

Mass loadingis defined as the concentration of suspended matter in a vertical column in the ocean. This quantity is referred to as "turbidity" in the IORD because it is used to derive both rates of sediment deposition and optical clarity. The depth of the vertical column is specified by the vertical cell size. Turbidity may be derived from ocean color data. The requirements below apply only under clear conditions.

Units: mg/l

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.7.11-1 | a. Horizontal Cell Size | 1.3 km | 0.25 km |
| 40.7.11-2 | b. Horizontal Reporting Interval | (TBD) | (TBD) |
| 40.7.11-3 | c. Horizontal Coverage | Oceans | Oceans |
| 40.7.11-4 | d. Vertical Cell Size | Surface layer ((TBD) m) | (TBD) |
| 40.7.11-5 | e. Measurement Range | (TBD) | 0 - 100 mg/l |
| 40.7.11-6 | f. Measurement Accuracy | Greater of 30 % or (TBD) | 0.1 mg/l |
| 40.7.11-7 | g. Measurement Precision | (TBD) | 0.1 mg/l |
| 40.7.11-8 | h. Mapping Uncertainty | (TBD) | 0.5 km |
| 40.7.11-9 | i. Maximum Local Average Revisit Time | 48 hrs | 24 hrs |
| 40.7.11-10 | j. Maximum Local Refresh | (TBD) | (TBD) |

## 40.8 Space Environmental EDRs (TBR)

### 40.8.1 Auroral Boundary

The auroral boundaries are the edges (both equatorward and poleward) of the auroral zones. A more precise definition of these boundaries can only be formulated within the context of the measurement technique involved. The locations of the auroral boundaries, which change as a function of geomagnetic activity, are required as input to magnetospheric and ionospheric models at 50WS. Of greatest (but not sole) importance is the latitude of the equatorward boundary at midnight. Knowledge of auroral boundaries contributes in a minor sense to satisfaction of the Ionospheric Scintillation EDR (EDR 40.8.11), since the location of the auroral oval constrains the occurrence of scintillation phenomena at high latitudes.

Units: Degrees latitude and longitude

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.8.1-1 | a. Horizontal Reporting Interval | N/A | 10 km along boundary (TBR) |
| 40.8.1-2 | b. Horizontal Coverage | (TBS) | (TBS) |
| | c. Measurement Range | | |
| 40.8.1-3 | 1. Latitude | Abs. value > 40 deg | Abs. value > 40 deg |
| 40.8.1-4 | 2. Longitude | 0 - 360 deg | 0 - 360 deg |
| 40.8.1-5 | d. Measurement Uncertainty | 50 km | 10 km |
| 40.8.1-6 | e. Reporting Frequency (for in-track derived boundary) | (TBS) | (TBS) |
| 40.8.1-7 | f. Maximum Local Average Revisit Time (for imagery derived boundary) | (TBS) | (TBS) |

### 40.8.2 Total Auroral Energy Deposition

An estimate of the total (global average) upper atmospheric auroral heat input due to particle precipitation. Contributions due to precipitating electrons and ions must be separately determined. Total Auroral Energy Deposition is an input to upper atmospheric density models. A change in energy deposition of $10^{-4}$ W/m$^2$ is consistent with a change in upper atmospheric temperature of 15 degrees.

Units: watts/m$^2$

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.8.2-1 | a. Horizontal Coverage | Auroral Zones | Auroral Zones |
| | b. Measurement Range | | |
| 40.8.2-2 | 1. Electrons | $10^{-4}$ - 1 W/m$^2$ | 5 x $10^{-5}$ - 1 W/m$^2$ |
| 40.8.2-3 | 2. Ions | $10^{-4}$ - 0.1 W/m$^2$ | 5 x $10^{-5}$ - 0.1 W/m$^2$ |
| 40.8.2-4 | c. Measurement Uncertainty | Greater of $10^{-4}$ W/m$^2$ or 20 % | Greater of 5x$10^{-5}$ W/m$^2$ or 10 % |
| 40.8.2-5 | d. Reporting Frequency | (TBS) | (TBS) |

## 40.8.3 Auroral Imagery

Two-dimensional (along/cross track) images of the Earth's auroral regions, taken in one or more of several wavelength intervals in the infrared, visible, far ultraviolet (FUV), and x-ray portions of the spectrum. The table below gives some information on requirements for the far-ultraviolet; requirements for other spectral ranges are TBR. This imagery can provide information on the location of the Auroral Boundary (EDR 40.8.1) and regions of enhanced auroral activity, and can be used to infer characteristics of precipitating particles.

Units:
Wavelength: nm
For visible/IR imagery: watts/$m^2$
For FUV imagery: rayleighs
For x-ray imagery: (TBD)

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.8.3-1 | a. Horizontal Cell Size | 20 km | 10 km |
| 40.8.3-2 | b. Horizontal Reporting Interval | Horizontal Cell Size | Horizontal Cell Size |
| 40.8.3-3 | c. Horizontal Coverage | (TBS) | Auroral Zones |
| 40.8.3-4 | d. Measurement Range | 120-180 nm (TBR) | 80-250 nm (TBR) |
| 40.8.3-5 | e. Measurement Uncertainty | 10 % | 5 % |
| 40.8.3-6 | f. Mapping Uncertainty | 20 km | 10 km |
| 40.8.3-7 | g. Maximum Local Average Revisit Time | (TBS) | (TBS) |

## 40.8.4 Electric Fields

Electric fields in the ionosphere cause transport of plasma and, at high latitudes, provide a "footprint" of the magnetospheric fields. Thus, electric fields are required inputs for both ionospheric and magnetospheric specification models. Electric fields are also needed to determine the amount of joule heating in the auroral region, which is an input to neutral atmospheric models. Electric fields are three-component vector quantities.

Units: mv/meter

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.8.4-1 | a. Horizontal Reporting Interval | (TBR) | (TBS) |
| 40.8.4-2 | b. Horizontal Coverage | In-track | In-track |
| 40.8.4-3 | c. Measurement Range | 0-150 mv/meter | 0-250 mv/meter |
| 40.8.4-4 | d. Measurement Uncertainty | 3.0 mv/meter | 0.1 mv/meter |
| 40.8.4-5 | e. Measurement Precision | 2.0 mv/meter | 0.1 mv/meter |
| 40.8.4-6 | f. Local Time Range | (TBS) | (TBS) |

## 40.8.5 Electron Density Profiles/Ionospheric Specification

The ionosphere is that portion of the Earth's upper atmosphere which is composed of electrically charged particles (electrons and various ions). A complete vertical electron density profile would extend from the D and E regions at altitudes between 60 and 150 km, through the F region within which the electron density reaches a maximum value nominally between altitudes of 250-350 km, through the topside up to 3,000 km, and into the plasmasphere. The Air Force requires global ionospheric specification to meet a number of operational needs. Electron density profile measurements, to include measurements of various important parameters associated with a complete profile, are required as inputs to and to augment the outputs of operational ionospheric models. Profile measurements above the NPOESS altitude are not required. The term TEC in the following table refers to the Total Electron Content associated with a complete vertical profile, ground to 36,000 km altitude, unless otherwise indicated.

Units:
NmF2 /electron density: $cm^{-3}$
HmF2: km
TEC: $10^{16}/m^2$ = 1 TEC unit

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.8.5-1 | a. Horizontal Reporting Interval | Horizontal Cell Size | Horizontal Cell Size |
| 40.8.5-2 | b. Vertical Reporting Interval (profiles only, below NPOESS altitude) | Vertical Cell Size | Vertical Cell Size |
| | c. Horizontal Cell Size | | |
| 40.8.5-3 | 1. 0-30° latitude | 200 km | 100 km |
| 40.8.5-4 | 2. 30-50° latitude | 500 km | 250 km |
| 40.8.5-5 | 3. 50-90° latitude | 100 km | 50 km |
| 40.8.5-6 | d. Vertical Cell Size (for profiles) | 10 km within 100 km of E/F peaks, 20 km elsewhere | 5 km |
| 40.8.5-7 | e. Horizontal Coverage | (TBS) | (TBS) |
| 40.8.5-8 | f. Vertical Coverage | 90-800 km | 50-2000 km |
| | g. Measurement Range | | |
| 40.8.5-9 | 1. Density at an arbitrary altitude below NPOESS (local density) | $3x10^5$ - $10^7$ $cm^{-3}$ | $10^4$ - $10^7$ $cm^{-3}$ |
| 40.8.5-10 | 2. TEC | 3 - 200 TEC units | 1 - 200 TEC units |
| 40.8.5-11 | 3. foF2 | 5 to 30 MHz | 1 to 30 MHz |
| | h. Measurement Uncertainty | | |
| 40.8.5-12 | 1. Density at an arbitrary altitude below NPOESS | **Greater of** 20 % or 3 $x10^5$ $cm^{-3}$ (TBR) | Greater of 5 % or $10^4$ $cm^{-3}$ |
| 40.8.5-13 | 2. NmF2 | 20 % | 5 % |
| 40.8.5-14 | 3. TEC | **Greater of** 20 % or 3 TEC units | 1 TEC unit |
| 40.8.5-15 | 4. HmF2 | 20 km | 5 km |
| 40.8.5-16 | 5. NmE | **Greater of** 20 % or $3x10^3$ $cm^{-3}$ | (TBS) |
| 40.8.5-17 | 6. HmE | 10 km (TBR) | (TBS) |
| 40.8.5-18 | 7. Topside scale height | 20 % (TBR) | (TBS) |
| 40.8.5-19 | 8. TEC above NPOESS | 3 TEC units | (TBS) |
| 40.8.5-20 | i. Maximum Local Average Revisit Time | (TBD) | (TBD) |

## 40.8.6 Geomagnetic Field

Vector measurements of the earth's magnetic field at NPOESS altitude. There are two uses for this data. First, to determine magnetic field aligned current boundaries as inputs to magnetospheric specification models. Second, as inputs to the World Magnetic Field Model. The latter use requires high accuracy. Because of the difference in accuracy requirements for these two uses, this parameter has two sets of thresholds and objectives (TBS), (thresholds specified below are for the higher accuracy requirement).

Units: nanotesla (nT)

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.8.6-1 | a. Horizontal Reporting Interval | 10 km | 500 m |
| 40.8.6-2 | b. Horizontal Coverage | In-track | In-track |
| 40.8.6-3 | c. Measurement Range | 20,000-60,000 nT | 10,000-60,000 nT (TBR) |
| 40.8.6-4 | d. Measurement Uncertainty (magnitude) | 6 nT RMS | 2 nT |
| 40.8.6-5 | e. Mapping Uncertainty | 100 m SEP | (TBS) |
| 40.8.6-6 | f. Measurement Accuracy of Vector Direction | 1.0 arc min | 0.6 arc min |
| 40.8.6-7 | g. Measurement Precision | 2 nT | 0.5 nT |
| 40.8.6-8 | h. Local Time Range | (TBS) | (TBS) |

## 40.8.7 In-situ Ion Drift Velocity

Measurement of the three dimensional ion drift velocity at NPOESS altitude.

Units: km/sec

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.8.7-1 | a. Horizontal Reporting Interval | (TBS) | (TBS) |
| 40.8.7-2 | b. Horizontal Coverage | In-track | In-track |
| 40.8.7-3 | c. Measurement Range | 0-3 km/sec | 0-5 km/sec |
| 40.8.7-4 | d. Measurement Uncertainty | 75 m/sec | 50 m/sec |
| 40.8.7-5 | e. Measurement Precision | 50 m/s | 25 m/s |
| 40.8.7-6 | f. Local Time Range | (TBD) | (TBD) |

## 40.8.8 In-situ Plasma Density

Measurements of the total thermal electron density at NPOESS altitude. Used to improve the accuracy of remotely sensed electron density profiles at altitudes near the NPOESS altitude and as a minor input to ionospheric specification models. Also used to quantitatively assess ionospheric model performance (see EDR 40.8.11). Measurements of ion densities may also be required (TBS).

Units: $cm^{-3}$

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.8.8-1 | a. Horizontal Reporting Interval | 50 km | 10 km |
| 40.8.8-2 | b. Horizontal Coverage | In-track | In-track |
| 40.8.8-3 | c. Measurement Range | $5x10^3$ - $5x10^6$ $cm^{-3}$ | $10^2$ - $10^7$ $cm^{-3}$ |
| 40.8.8-4 | d. Measurement Uncertainty | 20 % | 5 % |
| 40.8.8-5 | e. Local Time Range | (TBD) | (TBD) |

## 40.8.9 In-situ Plasma Fluctuations

Measurement of electron density fluctuations at NPOESS altitude. The desired products are the RMS value of □n/n, where n is the local electron density (see EDR 40.8.8), and the spectral index for the fluctuation spectrum, determined for the indicated range of scale sizes. These parameters can be used to derive an estimate of $C_kL$, a height-integrated irregularity strength parameter which is an input to ionospheric scintillation models (see EDR 40.8.11).

Units:
Spectral Index: (TBS)
□n/n: Dimensionless

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.8.9-1 | a. Horizontal Reporting Interval | 100 km | 5 km (TBR) |
| 40.8.9-2 | b. Horizontal Coverage | In-track | In-track |
| | c. Measurement Range | | |
| 40.8.9-3 | 1. Fluctuation Scale Length | (TBS) | (TBS) |
| 40.8.9-4 | 2. Spectral Index | 2-5 | 1 - 10 |
| 40.8.9-5 | 3. □n/n | $10^{-2}$ - 1 | $10^{-4}$ - 1 |
| | d. Measurement Uncertainty | | |
| 40.8.9-6 | 1. Spectral Index | (TBS) | (TBS) |
| 40.8.9-7 | 2. □n/n | (TBS) | (TBS) |
| 40.8.9-8 | e. Local Time Range | (TBS) | (TBS) |

## 40.8.10 In-situ Plasma Temperatures

Measurement of both the electron and ion temperatures at NPOESS altitude. Temperatures in the mid-latitudes are used to determine electron density scale heights for input to operational ionospheric models (see EDR 40.8.11).

Units: Degrees Kelvin (K)

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.8.10-1 | a. Horizontal Reporting Interval | 100 km | 10 km |
| 40.8.10-2 | b. Horizontal Coverage | In-track | In-track |
| 40.8.10-3 | c. Measurement Range | 500 - 10,000 K | 500 - 10,000 K |
| 40.8.10-4 | d. Measurement Uncertainty | 10 % | 5 % |

## 40.8.11 Ionospheric Scintillation

Temporal and spatial fluctuations in ionospheric electron density lead to fading or disruption of trans-ionospheric communication and radar signals, a phenomenon known as scintillation. The extent of the effect depends on the relative motion of the ionosphere and the signal source, the frequency of transmission, and the amplitude and spectral characteristics of the ionospheric fluctuations. Direct measurements of scintillation in terms of amplitude and phase fluctuation indices $S_4$ and sigma-ø are required. In addition, knowledge of the location of the auroral boundary (EDR 40.8.1) is required input to operational models of scintillation.

Units:
$S_4$: Dimensionless
sigma-ø: radians

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.8.11-1 | a. Horizontal Cell Size | 100 km | 50 km |
| 40.8.11-2 | b. Horizontal Coverage | (TBS) | (TBS) |
| | c. Measurement Range | | |
| 40.8.11-3 | 1. $S_4$ | 0.1 - 1.5 | (TBS) |
| 40.8.11-4 | 2. sigma-ø | 0.1 - 20 radians | (TBS) |
| | | | |
| | d. Measurement Uncertainty | | |
| 40.8.11-5 | 1. $S_4$ | 0.1 | (TBS) |
| 40.8.11-6 | 2. sigma-ø | 0.1 radian | (TBS) |
| 40.8.11-7 | e. Local Time Range | (TBS) | (TBS) |

## 40.8.12 Neutral Density Profiles/Neutral Atmospheric Specification

Measurement of neutral density profiles. Profiles are to be used, along with other geophysical quantities, as inputs to upper atmospheric density models.

Units:
Individual Species ($N_2$, $O_2$, O) Density: $cm^{-3}$
Total Density: $g/cm^{-3}$

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.8.12-1 | a. Horizontal Reporting Interval | 500 km, in track | 50 km |
| 40.8.12-2 | b. Vertical Reporting Interval | Vertical Cell Size | Vertical Cell Size |
| 40.8.12-3 | c. Horizontal Coverage | (TBS) | (TBS) |
| 40.8.12-4 | Not Used | | |
| | d. Vertical Cell Size | | |
| 40.8.12-5 | 1. Up to 120 km | 10 km | 0.5 km |
| 40.8.12-6 | 2. Above 120 km | 10 km | 3 km |
| 40.8.12-7 | e. Vertical Coverage | 100 - 750 km | 90 - 1600km |
| | f. Measurement Range | | |
| 40.8.12-8 | 1. Density | $3x10^{-9}$ to $2x10^{-19}$ $g/cm^3$ | (TBS) |
| 40.8.12-9 | 2. Number density | $9x10^4$ to $6x10^{13}$ $cm^{-3}$ | (TBS) |
| | g. Measurement Uncertainty | | |
| 40.8.12-10 | 1. 100 to 500 km | 15 % | |
| 40.8.12-11 | 2. > 500 km | 20 % | |
| 40.8.12-12 | 3. 90 to 500 km | | 5 % |
| 40.8.12-13 | 4. 500-700 km | | 10 % |
| 40.8.12-14 | 5. 700-1600 km | | 15 % |
| 40.8.12-15 | h. Maximum Local Average Revisit Time | (TBS) | (TBS) |

## 40.8.13 Radiation Belt/Low Energy Solar Particles

Measurements of particles through this energy range are required to serve as inputs to models of the auroral ionosphere, especially D-region effects (see EDR 40.8.5) and to determine the boundary and extent of the polar cap (EDR 40.8.1) and provide inputs to magnetospheric models. This information is required to assist in the analysis of satellite anomalies involving surface charging and, at the higher energies, deep dielectric charging and radiation damage. Measurements of ions and electrons are required, including energy spectrum information. Particle measurements are required for pitch angles, both within the atmospheric loss cone and near local mirroring, to determine that portion of the particle population entering the atmosphere.

Units:
Energy: keV or MeV
Flux: $m^{-2}sec^{-1}ster^{-1}$

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.8.13-1 | a. Horizontal Reporting Interval | (TBS) | (TBS) |
| 40.8.13-2 | b. Horizontal Coverage | In-track | In-track |
| | c. Measurement Range (electrons and ions) | | |
| 40.8.13-3 | 1. Energy | 30 keV - 10 MeV in 8 bands | (TBS) |
| 40.8.13-4 | 2. Flux | $10^5$ - $10^{11}$ | (TBS) |
| 40.8.13-5 | d. Pitch Angle Resolution | (TBS) | (TBS) |
| 40.8.13-6 | e. Measurement Precision (flux) | 5 % (TBR) | 1 % (TBS) |
| 40.8.13-7 | f. Measurement Accuracy (flux) | 20 % | 10 % |
| 40.8.13-8 | g. Number of Platforms | (TBS) | (TBS) |

## 40.8.14 Solar/Galactic Cosmic Rays

Definition:
Measurements of particles through this energy range are required to serve as inputs to models of the auroral ionosphere, especially D-region effects (see EDR 40.8.5) and to determine the boundary and extent of the polar cap (EDR 40.8.1). In addition, this information is required to assist in the analysis of satellite anomalies, semiconductor and solar cell radiation damage, and radiation hazard to astronauts and aircraft personnel. Measurements of ion energy spectrum and composition are required. Particle measurements are required for pitch angles, both within the atmospheric loss cone and near local mirroring, to discriminate that portion of the particle population entering the atmosphere from that which is trapped.

Units:
Energy: MeV/nucleon
Flux: $m^{-2}sec^{-1}ster^{-1}$

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.8.14-1 | a. Horizontal Reporting Interval | (TBS) | (TBS) |
| 40.8.14-2 | b. Horizontal Coverage | In-track | In-track |
| | c. Measurement Range | | |
| 40.8.14-3 | 1. Proton and Alpha Energies | [>10] - [1000] in 6 bands | [>10] - [>1000] in 8 bands |
| 40.8.14-4 | 2. Heavy Ion (CNO & Fe) Energies | [>10] - [100] in 4 bands | (TBS) |
| 40.8.14-5 | 3. Proton Flux | $10^3$ - $10^{10}$ | $10^2$ - $10^{10}$ |
| 40.8.14-6 | 4. Alpha Particle Flux | $10^2$ - $10^8$ | $10^2$ - $10^8$ |
| 40.8.14-7 | 5. Heavy Ion (CNO) Flux | $10^0$ - $10^7$ | $10^{-2}$ - $10^7$ |
| 40.8.14-8 | 6. Heavy Ion (Fe) Flux | $10^{-1}$ - $10^6$ | $10^{-3}$ - $10^6$ |
| 40.8.14-9 | d. Pitch Angle Resolution | (TBS) | (TBS) |
| 40.8.14-10 | e. Measurement Precision (flux) | 5 % (TBS) | 1 % (TBS) |
| 40.8.14-11 | f. Measurement Uncertainty (flux) | 20 % | 10 % |
| 40.8.14-12 | g. Number of Platforms | (TBS) | (TBS) |

## 40.8.15 Solar Extreme Ultraviolet Flux

Measurements of the full disk solar flux within several wavelength bands between 5 and 175 nm. Used as inputs to neutral atmospheric and ionospheric models.

Units:
Wavelength: nm
Flux: $W/m^2$

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.8.15-1 | a. Measurement Range | 5 - 130 nm in 4 channels | 1 - 175 nm in 10 channels |
| 40.8.15-2 | b. Measurement Uncertainty | Greater of $10^{-4}$ $W/m^2$ or 20 % | Greater of $5x10^{-5}$ $W/m^2$ or 10 % |
| 40.8.15-3 | c. Reporting Frequency | (5 hours) | (TBS) |

## 40.8.16 Supra-Thermal through Auroral Particles

In-situ measurements of moderately energetic (< 30 keV) electrons and ions, primarily in the auroral regions. These measurements are input to space environment models and are used for low earth orbit anomaly assessments (surface charging). The mean energy and flux of the precipitating particles are particularly desired, although complete energy spectra are also needed. Measurements of particle energy spectra as a function of pitch angle are also desired. In particular, measurements inside and outside the loss cone angle are needed.

Units:
Energy: eV or keV
Flux: $m^{-2}sec^{-1}ster^{-1}keV^{-1}$

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| 40.8.16-1 | a. Horizontal Reporting Interval | (TBS) | (TBS) |
| 40.8.16-2 | b. Horizontal Coverage | In-track | In-track |
| | c. Measurement Range (electrons and ions) | | |
| 40.8.16-3 | 1. Energy | 30 eV - 30 keV | (TBS) |
| 40.8.16-4 | 2. Flux | $10^8$ - $10^{15}$ | (TBS) |
| 40.8.16-5 | d. Pitch Angle Resolution | (TBS) | (TBS) |
| | e. Measurement Precision | | |
| 40.8.16-6 | 1. Energy | $\Delta E/E = 0.2$ | $\Delta E/E = 0.1$ |
| 40.8.16-7 | 2. Flux | 5 % | 1 % |
| 40.8.16-8 | f. Measurement Accuracy | 20 % | 10 % |
| 40.8.16-9 | g. Local Time Range | (TBS) | (TBS) |

## 40.8.17 Upper Atmospheric Airglow (TBR)

The Earth's upper atmosphere consists of neutral and ionized particles, most of which radiate at various wavelengths due to a variety of physical processes dependent on solar illumination (day/night), particle species, and atmospheric conditions. Measurements of this "airglow" can be used to infer information about the ionosphere (see EDR 40.8.5), neutral atmosphere (EDR 40.8.12), and the solar extreme ultraviolet flux (EDR 40.8.15). In addition, airglow imagery in the equatorial region and on the nightside, after sunset, can provide signatures of ionospheric disturbances associated with scintillation (EDR 40.8.11). Two types of airglow measurement geometry are possible: limb and disk. Disk measurements in the auroral zone are closely related to the Auroral Imagery requirement (EDR 40.8.3).

Units: rayleighs

| Para. No. | | Thresholds | Objectives |
|---|---|---|---|
| | a. Horizontal Cell Size | | |
| 40.8.17-1 | 1. Limb | 750 km | 100 km |
| 40.8.17-2 | 2. Disk, 0 - 30 deg latitude | 200 km | 100 km |
| 40.8.17-3 | 3. Disk, 30 - 50 deg latitude | 500 km | 250 km |
| 40.8.17-4 | 4. Disk, 50 - 90 deg latitude | 100 km | 10 km |
| | b. Horizontal Reporting Interval | | |
| 40.8.17-5 | 1. Limb | 750 km | 100 km |
| 40.8.17-6 | 2. Disk | 100 km | 10 km |
| 40.8.17-7 | c. Vertical Cell Size (Limb) | 20 km | 5 km |
| 40.8.17-8 | d. Vertical Reporting Interval (Limb) | 20 km | 5 km |
| | e. Horizontal Coverage | | |
| 40.8.17-9 | 1. Limb | (TBS) | (TBS) |
| 40.8.17-10 | 2. Disk | (TBS) | (TBS) |
| 40.8.17-11 | f. Vertical Coverage (Limb) | (TBS) | (TBS) |
| | g. Measurement Range | | |
| 40.8.17-12 | 1. Limb, 83.4 nm | 20 - 1000 R | 10 - 1000 R |
| 40.8.17-13 | 2. Limb, 91.1 nm | (TBS) | (TBS) |
| 40.8.17-14 | 3. Limb, 135.6 nm | 0.2 - 10 kR | 0.1 - 10 kR |
| 40.8.17-15 | 4. Limb, 140 - 180 nm | 0.2 - 30 kR | 0.1 - 30 kR |
| 40.8.17-16 | 5. Limb, 140 - 150 nm | (TBS) | (TBS) |
| 40.8.17-17 | 6. Limb, 165 - 180 nm | (TBS) | (TBS) |
| 40.8.17-18 | 7. Disk, 121.6 nm | 1 - 30 kR | 0.5 - 30 kR |
| 40.8.17-19 | 8. Disk, 135.6 nm | 4 - 4000 kR | 1 - 4000 R |
| 40.8.17-20 | 9. Disk, 140 - 180 nm | 4 - 5000 kR | 1 - 5000 R |
| 40.8.17-21 | 10. Disk, 140 - 150 nm | (TBS) | (TBS) |
| 40.8.17-22 | 11. Disk, 165 - 180 nm | (TBS) | (TBS) |
| 40.8.17-23 | 12. Disk, 630.0 nm | (TBS) | (TBS) |
| 40.8.17-24 | h. Measurement Accuracy | 10 % (TBR) | 5 % |
| 40.8.17-25 | i. Measurement Precision | (TBS) | (TBS) |
| 40.8.17-26 | j. Local Time Range (Limb) | (TBS) | (TBS) |
| 40.8.17-27 | k: Maximum Local Average Revisit Time (Disk) | (TBS) | (TBS) |

## 40.9 Notes on Space Environmental EDRs

This section provides additional clarification of the nature of the Space Environment EDRs and the connections between them. Examples of techniques for making these measurements are given in order to illustrate and clarify the EDR requirements. These examples are not meant to indicate a program office preference for a particular method for meeting requirements. Alternate approaches which satisfy requirements will be considered equally.

### 40.9.1 Auroral Boundary

A measurement of the auroral boundary has typically been obtained in one of two ways. (1) In-situ energetic particle measurements (see EDR 40.8.16) can provide an indication of the boundary location in the satellite track. A statistical model of the auroral oval can then be used to extrapolate the location of the boundary to other local times. (2) An optical sensor (see EDR 40.8.3) which scans the Earth's disk can provide a two-dimensional image of the boundary. This can be done at various wavelengths, including the far ultraviolet and visible, but the latter is only useful at night, since auroral signals are overwhelmed during the day by scattered sunlight. A far-ultraviolet sensor can make auroral boundary measurements during both day and night.

### 40.9.2 Total Auroral Energy Deposition

Total auroral energy deposition is calculated from measurements of the mean energy and flux of precipitating particles. These measurements may be made in one or both of two ways. (1) In-situ measurements of precipitating ion and electron fluxes (see EDR 40.8.16) may be combined with a statistical model of auroral activity to provide an estimate of the global average. (2) Far-ultraviolet images, or possibly a combination of far-ultraviolet and x-ray images (see EDR 40.8.3), can be used to derive mean precipitating particle energies and fluxes over a wide area, which can then be used to estimate the global average.

### 40.9.3 Auroral Imagery

Various products can be obtained from auroral imagery, depending on the wavelength(s) imaged. All wavelengths provide information on the location of the Auroral Boundary (EDR 40.8.1), and also allow identification of regions of enhanced auroral activity. (Such regions can impact communications and radar systems.) Infrared and visible wavelength imagery only provide this type of information at night, since auroral signals are overwhelmed during the day by scattered sunlight. Far ultraviolet images involving specific wavelength intervals, or a combination of far-ultraviolet and x-ray images, can also be used to determine maps of precipitating particle mean energy and flux (see EDR 40.8.16). Such maps could subsequently be used to determine the Total Auroral Energy Deposition (see EDR 40.8.2), as well as E-region electron densities in the auroral zone (see EDR 40.8.5). In combination with in-situ particle measurements (EDR 40.8.7), far-ultraviolet images can be used to calculate changes in upper atmospheric neutral densities due to auroral activity (see EDR 40.8.12).

### 40.9.4 Electric Fields

Electric fields may be inferred from measurements of ion drift velocities (see EDR 40.8.7).

### 40.9.5 Electron Density Profiles/Ionospheric Specification

A variety of techniques exist for making measurements of various portions of ionospheric electron density profiles. These include in-situ measurements of plasma parameters (EDRs 40.8.8 and 40.8.10), optical remote sensing techniques (EDRs 40.8.3 and 40.8.17), active and passive high frequency remote sensing, and total electron content measurements along lines-of-sight to GPS satellites. The following is a partial list of ionospheric parameters which may be useful to measure or infer as part of an effort to construct complete vertical profiles.

| Parameter | Definition |
|---|---|
| $N_mF2$ | Peak electron density in the F-region |
| $H_mF2$ | Altitude at which NmF2 occurs for a particular profile |
| $N_mE$ | Peak electron density in the E-region |
| $H_mE$ | Altitude at which NmE occurs for a particular profile |
| $H_{top}$ | Topside electron density scale height |
| $H_{trans}$ | Transition altitude between dominance of oxygen and lighter ions |
| $N_{NPOESS}$ | In-situ electron density at NPOESS altitude |
| $TEC_{topside}$ | Total Electron Content above NPOESS altitude |

### 40.9.6 Geomagnetic Field

No comments.

### 40.9.7 In-situ Ion Drift Velocity

In-situ ion drift velocities can be used to determine electric fields (see EDR 40.8.4).

### 40.9.8 In-situ Plasma Density

No comments.

### 40.9.9 In-situ Plasma Fluctuations

No comments.

### 40.9.10 In-situ Plasma Temperatures

No comments.

### 40.9.11 Ionospheric Scintillation

In addition to direct measurements of amplitude and phase fluctuations, airglow imagery (EDRs 40.8.3 and 40.8.17) of ionospheric signatures in the far ultraviolet can also indicate the possible presence of scintillation for some geophysical regions.

### 40.9.12 Neutral Density Profiles/Neutral Atmospheric Specification

One technique for obtaining neutral densities involves measurement of airglow in the far ultraviolet (see EDR 40.8.17).

### 40.9.13 Radiation Belt/Low Energy Solar Particles

No comment.

### 40.9.14 Solar/Galactic Cosmic Rays

No comment.

## 40.9.15 Solar Extreme Ultraviolet Flux

A minimal estimate of the integrated solar EUV flux below 45 nm can be obtained from measurements of far ultraviolet airglow (see EDR 40.8.17). This measurement complements, but does not satisfy threshold requirements for this EDR.

## 40.9.16 Supra-Thermal through Auroral Particles

These measurements have a variety of applications. These include calculation of in-track electron density profiles (see EDR 40.8.5) in the auroral zone E-region, calculation of total auroral energy deposition (EDR 40.8.2), and calculation of the auroral boundary location (EDR 40.8.1).

## 40.9.17 Upper Atmospheric Airglow (TBR)

Two types of airglow measurement geometry are possible: limb and disk. The limb-viewing geometry provides the best accuracy of the two for retrieval of ionospheric and neutral atmospheric parameters and comes the closest to retrieving complete vertical profiles. However, the long line-of-sight along the limb makes accurate measurements difficult in the auroral zone, with its high spatial variability. The disk-viewing geometry provides a more detailed information on horizontal structures in the ionosphere on the nightside, but requires additional assumptions to interpret the data, particularly on the dayside and in the auroral zone. Disk measurements in the auroral zone are closely related to the Auroral Imagery requirement (EDR 40.8.3).

The following emission features represent a subset of the possible emission features which could be measured to yield information on electron and neutral density profiles:

| Wavelength | Upper Atmospheric Source/EDR Product |
|---|---|
| 83.4 nm | O+ ion/Dayside electron densities (limb only) |
| 91.1 nm | O neutral/Nightside electron densities (limb or disk) |
| 121.6 nm | H neutral/Auroral zone proton fluxes (disk only) |
| 135.6 nm | O neutral/Night (limb & disk) and dayside (disk only) electron densities & dayside neutral densities and solar EUV |
| 140-150 nm | N2 neutral/Dayside neutral densities (limb & disk) and auroral electron fluxes (disk only) |
| 165-180 nm | N2 neutral/Dayside neutral (limb & disk) and electron (disk only) densities and solar EUV & auroral electron fluxes (disk only) |
| 630.0 nm | O neutral/Nightside electron densities |